2018

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http://hdl.handle.net/10026.1/12838

http://dx.doi.org/10.24382/924
University of Plymouth

Investigating the Moment when Solutions emerge in Problem Solving

by

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UNIVERSITY OF PLYMOUTH

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Computing, Electronics and Mathematics

Plymouth 2018

Acknowledgements

This work has been funded through a full studentship by the University of Plymouth and supported by the additional training receievd through the CogNovo programme. CogNovo is funded by EU Marie Skłodowska-Curie programme (FP7-PEOPLE-2013-ITN-604764) and the University of Plymouth.

This work is part of the CogNovo Doctoral Training Programme and has been supervised by the director of studies Dr. Guido Bugmann (School of Computing, Electronics and Mathematics) and the additional supervisors Dr. Jeremy Goslin (School of Psychology), and Dr. Katharine Willis (School of Art, Design and Architecture).

Abstract

Investigating the Moment when Solutions emerge in Problem Solving

Frank Lösche

At some point during a creative action something *clicks*, suddenly the prospective problem solver *just knows* the solution to a problem, and a feeling of joy and relief arises. This phenomenon, called *Eureka experience*, *insight*, *Aha moment*, *hunch*, *epiphany*, *illumination*, or *serendipity*, has been part of human narrations for thousands of years. It is the moment of a subjective experience, a surprising, and sometimes a life-changing event. In this thesis, I narrow down this moment 1. conceptually, 2. experientially, and 3. temporally. The concept of emerging solutions has a multidisciplinary background in Cognitive Science, Arts, Design, and Engineering. Through the discussion of previous terminology and comparative reviews of historical literature, I identify sources of ambiguity surrounding this phenomenon and suggest unifying terms as the basis for interdisciplinary exploration. Tracking the experience based on qualitative data from 11 creative practitioners, I identify conflicting aspects of existing models of creative production. To bridge this theoretical and disciplinary divide between iterative design thinking and sequential models of creativity, I suggest a novel multi-layered model. Empirical support for this proposal comes from *Dira*, a computer-based open-ended experimental paradigm. As part of this thesis I developed the task and 40 unique sets of stimuli and response items to collect dynamic measures of the creative process and evade known problems of insightful tasks. Using *Dira*, I identify the moment when solutions emerge from the number and duration of mouse-interactions with the on-screen elements and the 124 participants' self-reports. I provide an argument for the multi-layered model to explain a discrepancy between the timing observed in *Dira* and existing sequential models. Furthermore, I suggest that *Eureka moments* can be assessed on more than a dichotomous scale, as the empirical data from interviews and *Dira* demonstrates for this rich human experience. I conclude that the research on *insight* benefits from an interdisciplinary approach and suggest *Dira* as an instrument for future studies.

Authors declaration

At no time during the registration for the research degree has the author been registered for any other University award, without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at University of Plymouth has not formed part of any other degree for either at the University or at another establishment.

This study was financed with the aid of a studentship from the University of Plymouth.

A programme of advanced study was undertaken under the umbrella of CogNovo, an innovative doctoral research training funded by University of Plymouth and the EU Marie Skłodowska-Curie programme (FP7-PEOPLE-2013-ITN-604764). This included week-long workshops on *Research Methods*, *Experimental Methods*, *Computational Modeling*, *Public Outreach and Social Innovation*, *Entrepreneurship*, *Scientific Mythodologies*, and *The Neural Basis For Creativity*.

Relevant scientific seminars and conferences were regularly attended at which work was often presented; external institutions were visited for consultation purposes and several papers prepared for publication.

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Word count of main body of thesis: 56263

Peer reviewed publications

Kristensen, M. S., Loesche, F., & Maranan, D. S. (2017, November 21). Navigating Cognitive Innovation. *AVANT*, *8*, 45–55. doi:10.26913/80s02017.0111.0005.

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University of California Berkeley, California, USA. Invited talk. *Collaboration and Cognitive Innovation: the Eureka Moment, Floating Brains, Reimagining the Body, and Acoustic Osteology* August 2018.

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Off the Lip 2017 CogNovo, University of Plymouth, UK. Event organisation. *CogNovo Colloquium on Experiences and Applications of Cognitive Innovation* August 2017.

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1 Introduction

It starts with a thought. The essence or the core of everything humans create is the moment when someone first thinks about it. It is the moment when people's mind passes from a state of not-knowing to knowing, or from a foreshadow to a notion; it brings clarity to a vague situation. Often, people had been engaged in this particular creation long before the pivotal moment moment, and having the idea or finding the solution is rarely the end. We humans, as thinkers, artists, and scientists, know and value the moment when an answer falls into its place, when a particular piece 'clicks', and when a solution emerges. In these moments some of us feel as if we were expected to call out 'Aha' or 'Eureka'. In this project, I set out to understand more about this 'Eureka moment'.

The defining Eureka experience was first mentioned about 2000 years ago in a textbook for students of Architecture. Much later eminent individuals described their scientific process through sudden Aha! moments, artists felt kissed by the muses, and authors broke their writer's block. From the 1920s on, psychologists situated 'illumination' at the centre of the creative process, biologists found genetic predisposition for creativity, and neuroscientists identified temporal correlates to insights. Yet, little is known about the exact timing of this moment and its interaction with the environment, the creator, or the created thought. I started this project with the aim to observe these sparse and fleeting moments and help creative partitioners to create advantageous environments for increasing these experiences, but I soon identified a lack of instruments and clarity of concepts. Often the creative process surrounding the 'illumination' is assessed through the created product and the creative person. This is a limitation derived from the conceptual framing of the insight phenomenon within creativity as discussed in Psychology. Phenomenologically similar concepts have been discussed before the psychological terms were established and are part of research in Engineering, Humanities, and the Arts. In chapter 2 I discuss the imprecise and ever-changing definition of central terms. Specifically, I identify a potential cause for this ambiguity even within the literature of Psychology through a comparative linguistic review reaching back as far as 90 years. Since the resulting vagueness of terms has negative effects on tools, measurements, and results, I suggest a consistent definition of the core terms related to the emerging phenomena. As I argue in chapter 2, this is a necessary step to rely on and compare tools, measurements, and results. Furthermore and as mentioned before, humans had known about these moments before creativity became a research object, and even before the term 'creativity' was coined.

I situate my research within the framework of 'Cognitive Innovation'. The research questions I tackle with my work starts before the term 'creativity' was coined and considers ideas currently not part of the creativity literature, which is predominantly related to Psychology. Framing my work within the psychological creativity research would, in conclusion, have limited the conceptual approach. The idea of 'Cognitive Innovation' is broader and was the initial multiple-disciplinary questions addressed through the CogNovo doctoral training centre at the University of Plymouth (Maranan et al., 2015). Relying on the initial conceptualisation by Denham (2014), I discussed the implications with my colleagues Kristensen et al. (2017). There we explained the recursive model introduced by Denham and Punt (2017), but add technology as an additional factor to the equation. Therefore, 'Cognitive Innovation' is best described as a drive to iterate over processes, knowledge, and perception on individual and group levels. This larger framework allows capturing the phenomenon of interest with fewer limitations in greater breadth and depth.

As part of my thesis, I follow the original trajectory of the term 'Eureka'. In chapter 3 I go back to architects to interview them about their creative process and 'Eureka moments'. In doing so, I identify a conflict between my collected data and the predominant theoretical models in Architecture and Cognitive Science. Furthermore, I worked with dancers and developed a tool to observe temporal patterns in dance improvisation (Łucznik & Loesche, 2017). With my colleagues, we identified moments of 'spontaneous synchronisation' that emerged during free dance improvisation (Łucznik, Loesche, Redding, & May, 2016, page 180). The results of both lines of work are discussed outside the field of creativity; in particular, the architects in chapter 3 distance themselves from the term 'creativity', even though their data suggests emerging phenomena similar to 'Eureka'. This links to the discussion in chapter 2 about several related terms used in the literature. Here I am concerned with the question if there are conceptual differences between the various emergent phenomena, or if they should be treated as terminological imprecision. This links to the discussion I had with a colleague regarding the relationship between bistable perception and convergent thinking tasks (Taranu & Loesche, 2017). By analysing a corpus of everyday phone conversations, another colleague and I looked at the timing of overcoming silent episodes in spontaneous conversation (Torre & Loesche, 2016). We develop a model of decision making that gives a better explanation for the observed response times.

The conflicts between observed behaviour in my studies and theoretical models discussed in the Cognitive Sciences became more and more apparent over time. Some of the underlying experimental work and discussions with my peers is documented in the publications mentioned above. My development and utilisation of 'Cognitive Innovation' provide additional theoretical support for the idea that there is more to the 'Eureka' phenomenon than meets the eye. In part, this is also captured in the multi-layered model introduced in section 3.5.2. From my observations and the literature discussed in chapter 2, the temporal aspects seem promising to address terminological imprecision and conceptual differences within the creative process and 'Eureka' phenomenon. However, I was not able to find an instrument to capture the temporal aspects of 'Eureka' free from assumptions based on disciplinary confinements of the existing literature.

Based on the findings from interviews with architects, I developed a novel experimental paradigm to observe the temporal aspects of the creative process. In chapter 4 I narrow down the moment when solutions emerge through a combination of behavioural and self-reported data from a series of experiments using 'Dira'. Some of these results have also been published in Loesche et al. (2018). In chapter 5 I link the interviews with architects and the resulting multi-layered model of creativity with the behavioural data from 'Dira' by observing how the data of one contributes to explaining the data of the other. Finally, in chapter 6 I provide a summary of my findings and my contribution to knowledge.

2 Staking a claim: An excavation in the literature

This chapter is dedicated to identifying existing knowledge about the moment when solutions emerge, the *Eureka moments* or, if you prefer other names, on the subject of insight, Aha! experience, serendipity, breakthrough thinking, vipassanā, tip-of-the-tongue, flash, penny dropping moment, anagnorisis, hunch, cognitive leap, revelation, intuition, epiphany... I analyse the underlying concept and the most important terms in part through a literature review, where I discuss how previous findings from different disciplines are connected. I also approach the topic through meta-analytic comparative reviews, where I actively draw inferences from cues such as gaps in the literature, terminology inconsistencies, and language ambiguity.

2.1 Methodology

For the narrative literature review, I report the methodological and theoretical findings on the topic of *Eureka moments*. The body of literature considered is not limited to a certain field; instead, I aim at providing an overview of different aspects of this instant, as seen from different perspectives. When I rediscover some original text on the phenomenon, the review gains an almost media archaeological aspect. A further expansion of this chapter beyond the scope a literature review is a comparative review of the origin of some of the terminology used on the topic today. Most notably I have done this in section 2.2.2.

The sheer length of the list of names given to the moment when solutions emerge demonstrates the interest in the topic. It also shows that the observations within different environments, disciplines, and from different perspectives did not converge to a commonly used term. While these terms have arguably different connotations in everyday language, the technical terms in various disciplines and the meaning of some words changes depending on the context they are used in. The study of the concept of 'Eureka moments' requires to take into account these different aspects and consider the attached ideas. In this thesis I rely on and relate to the concept of 'Cognitive Innovation' as a broad framework to capture these different aspects.

2.1.1 The relationship to Cognitive Innovation

To understand the different aspects of the work within the thesis it helps to be aware of the environment it was developed, namely CogNovo and 'Cognitive Innovation'. 'Cognitive Innovation' was introduced by Denham (2014, page 202) to highlight that "creativity or innovation does not occur in a vacuum. What is critically important for social and technological progress is innovation within appropriate constraints". Here she introduces the doctoral training centre *CogNovo* as a mean to link scientific research with social and technological innovation. Gummerum and Denham (2014) discusses the societal and distributed aspects of creativity and innovation in more detail, introducing the method of addressing interdisciplinary research questions in multidisciplinary teams with the expectation of some projects reaching transdisciplinary answers. Some of these projects have been explained in more detail by Maranan et al. (2015). In the same year, CogNovo invited to a first conference on 'Cognitive Innovation' and published the proceedings with contributions from different projects and therefore disciplines (Punt & Denham, 2015). The 'Off the Lip' conferences became an annual event to discuss the interdisciplinary aspects of the different lines of research within CogNovo. I edited one of the later proceedings and contributed the editorial for the published special edition of the AVANT Journal (Loesche & Łucznik, 2017). Throughout the CogNovo programme, the theory behind 'Cognitive Innovation' was discussed and advanced, most notably by Denham and Punt (2016) introducing the 'Cognitive Innovation Function'. In our contribution, Kristensen et al. (2017) provided a brader perspective on the history of the term and suggested to add technology as another aspect to the function. At the same time Punt and Denham (2017) highlighted collaboration as a necessity and irony as a useful addition to 'Cognitive Innovation'.

To grasp the breadth of the work associated with 'Cognitive Innovation' and realise how it goes beyond existing terminology and frameworks, it is useful to look at the other projects conducted within CogNovo, the hub of 'Cognitive Innovation'. Some of the published work is grounded within a single discipline and contributes for example to the literature of Linguistics (Torre, Goslin, & White, 2015; Torre, White, & Goslin, 2016), Human Robot Interaction (Melidis & Marocco, 2015), Machine Learning (Colin, Belpaeme, Cangelosi, & Hemion, 2016), Media Philosophy (Stamboliev, 2017), Somatics (Maranan, 2015), Neuro Imaging (Battaglini, Casco, Isaacs, Bridges, & Ganis, 2017; Ganis, Bridges, Hsu, & Schendan, 2016), (social) psychology (Briazu, Walsh, Deeprose, & Ganis, 2017; Kizilirmak, da Silva, Imamoglu, & Richardson-Klavehn, 2015; Tyagi, Hanoch, Hall, Runco, & Denham, 2017), Perception (Denham et al., 2018), Associative Learning (P. M. Jones & Zaksaite, 2017), Neural Systems (Fletcher & Wennekers, 2018), Alarm Design (Edworthy, Schlesinger, McNeer, Kristensen, & Bennett, 2017), Media Archeology (Catanese, Edmonds, & Lameris, 2015), and Artificial Intelligence (Lemarchand, 2018). Others bridge two or more disciplines, for example Psychology and Dance (Łucznik, 2015), Psychology and Artificial Intelligence (Kajić, Gosmann, Stewart, Wennekers, & Eliasmith, 2017; Kajic & Wennekers, 2015), Sound and medical care (Kristensen, Edworthy, & Özcan, 2016), or Philosophy and Play (Straeubig, 2015). Yet another set of publications discusses their work in a interdisciplinary context, for example when talking about virtual morality (K. B. Francis et al., 2017; Kathryn B. Francis, Gummerum, Ganis, Howard, & Terbeck, 2017; Kathryn B. Francis et al., 2016), playful soundscapes (Straeubig & Quack, 2016), or the rewards and challenges of interdiscplinary work (Briazu, 2017, 103; Torre et al., forthcoming).

My work towards this thesis was embedded in CogNovo and inspired by the discussion with my peers. In addition, the supervisory team that helped me to develop the methodology, consisted of a principal investigator interested in neural computations and robotics, a psycholinguist, and an architect. Adding my own background in computer science to the mix, the team was as 'multidisciplinary' as intended and discussed by Gummerum and Denham (2014). The phenomenon of interest is related to these different disciplines and the resulting research questions relating to the temporal aspects of 'Eureka' can be understood as interdisciplinary. Time and further discussions will tell how transdisciplinary the results, presented in this thesis and by Loesche et al. (2018) are. Nevertheless, this section hints towards the necessity of discussing the content of the thesis within 'Cognitive Innovation' and therefore outside the terminology and methodology of a single discipline. In the following sections I introduce the terminology related to the phenomemon of interest.

2.2 Terminology

Different names have been used to describe the moment when solutions emerge. One of the oldest preserved accounts of this moment uses the word *Eureka*, but depending on the context in which it is used, and the cultural, linguistic, or disciplinary background and personal preference of the writer, the exact term differs. Different names carry different connotations and, even if they aim to describe the same phenomenon, these meanings might have diverged over time. Other words that are closely related to the phenomenon of interest are *insight*, *illumination*, *aha*, and *epiphany*, and they will be discussed below. Often these words are used as compounds. For example, in the original text, the word *Eureka* is attached to *moment* and describes an *experience* that Archimedes had while solving a *problem* (Pollio, 15/1914). Consequently, in the scientific literature, *Eureka* is not only referred to as *Eureka moment*, but also in combination with other words such as *process* and *problem*. table 2.1 illustrates a few examples of the combinations known in the scientific literature. In the subsequent sections, I will follow some of these terms and their compounds. Based on the results of this examination, I summarise in section 2.2.8 how these terms are used within this thesis. By tracing their origin, their distinctively different uses, and by identifying their compounds, I converge towards the phenomenon itself.

	moment	process	experience	problem
Eureka	Holman (2012)	Shaw (1989)	Gruber (1981)	Lorge and Solomon (1955)
Aha	Kang et al. (2017), Kounios and Beeman (2009)		Danek et al. (2018), Jung-Beeman et al. (2004), Thagard and Stewart (2011), Topolinski and Reber (2010a)	
Insight	Hill and Kemp (2016), Tian et al. (2017), Wiltschnig et al. (2010)	Wangbing Shen et al. (2013), Wangbing Shen et al. (2017), Sheth et al. (2009), Sprugnoli et al. (2017), Yeh et al. (2014)	Danek et al. (2012), Ellen (1982), Jarman (2014, 2016), Wu et al. (2013), YUAN et al. (2016)	Weisberg and Alba (1981)
Epiphany	Dufwenberg et al. (2010)	Bowen (1982)	McDonald (2007)	

Table 2.1: The relationship between different names for emerging solutions and the related description.

2.2.1 Eureka

A *Eureka moment* is "an instant in which a scientific discovery is made, or a breakthrough occurs; a moment of inspiration; (in extended use) an exciting or significant experience", at least according to a dictionary ("Eureka moment", 2018). Relying on the term *Eureka moment*, it is also rather easy to communicate the topic of my research to colleagues and friends. Often I add 'the moment when it clicks, and you suddenly find the solution to a problem' as an additional description. Interestingly, the definition in the dictionary mentions scientific discoveries as the context. Furthermore, *breakthroughs*, *inspiration* and *exciting experiences* are mentioned. I will come back to these later in the chapter when I write about alternative names, associated phenomena, and related concepts. But first I want to introduce the *Eureka moment* in more detail, starting with the origin of the term.

Etymologically *eureka* (/juˈɹikə/) derives from the ancient Greek word $\varepsilon\upsilon\rho\eta\kappa\alpha$ (/he͜ú.rɛː.ka/) meaning *I have found (it)*. People are have reportedly been using this word for more than 2000 years as an interjection to celebrate discoveries and inventions. Its first documented use is attributed to the Syracusian mathematician Archimedes after discovering a solution to a problem he had been pondering on for some time: how to measure the volume of a crown, a body with an irregular shape. The story about the discovery of water displacement, made by chance in a bathtub in 250 BCE, was written down about 200 years after it happened by the Roman architect Pollio (15/1914). Since then the word has been used by other scientists to mark discoveries or express the feeling of joy originating from them. Another famous example is from Carl Friedrich Gauss' diary, where he wrote "$\varepsilon\upsilon\rho\eta\kappa\alpha$! $num = \triangle + \triangle + \triangle$" when he discovered that any positive number could be represented as the sum of three triangular numbers (Klein, 1903).

Similar to these anecdotes, the term *Eureka moment* describes the moment when people solve a problem. More precisely, it describes the moment when they transition from the state of not knowing the answer to being aware of a solution. In this combination, the word *Eureka* refers to the experiential aspect, while the *moment* connects it with the environment, with a potentially observable time when this happens. Before the *Eureka moment*, the prospective problem solver does not understand the solution. This implies that they do not know the answer, but they also do not know how they can reach the required answer. Once the transition has happened, they know the solution. This does not necessarily mean that they have found the exact answer yet, but they know a way to reach the solution. For example, Pollio (15/1914, Book IX, Paragraph 11) states that Archimedes had been "taking this [the *Eureka moment*] as the beginning of his discovery" before Pollio explains the details on how Archimedes found out that gold was missing. In the defining *Eureka moment* Archimedes, therefore, did not find the answer to the problem, but a solution on how to solve it.

Within the primary literature, there is no shared agreement on the exact definition of *Eureka moments*. Many texts contain descriptions, but it is up to the reader to find an exact interpretation. For example, K. S. Smith, Smith, and Stanford (2013, page 165) defines *Eureka* as "the moment that everything makes sense and a cohesive approach is made clear". Here they leave open what 'everything' is and to whom it makes sense. Other sources such as Sprugnoli et al. (2017, page 99), define these moments through *insight* as "Insight processes that peak in 'unpredictable moments of exceptional thinking'.". I will discuss the overlap between these terms and concepts in more detail in section 2.2.2. Interestingly many authors like Sprugnoli et al. (2017) use *Eureka moment*, *insight*, and *Aha* synonymously or provide circular definitions of one of the terms through the others.

The original account of the *Eureka moment* does not only describe what happened but also where and how. Besides the location in the bath and therefore away from the usual working environment, Pollio (15/1914, Book IX, Paragraph 10) reported that the solution arrived "without a moment's delay, and transported with joy". According to this description, the solution came suddenly and was accompanied by positive affect. A formal definition is missing in Rogers's (1954, page 256) publication, but here the *Eureka feeling* is one of three by-products of the creative act and seems to be a euphoric moment. It is also unexpected. Later definitions build on this accompanying phenomena by calling *Eureka moments* "moments of sudden, unexpected discovery" (Anderson, 2011). In addition to the suddenness, this author goes one step further by calling it unexpected, but without specifying to whom it is unexpected. This illustrates the different dimension of the phenomenon which I will discuss further in section 2.4.

Different aspects are behind the different compounds *Eureka* is used in and that are meant to highlight its different aspects. In table 2.1 I had already mentioned the *Eureka process*, a term coined by Shaw (1989, page 297) to highlight that "creativity is far from simply a cognitive process. It is a human process that has deep feelings [...] associated with it". Here the *Eureka process* surrounds the *creative process* for scientific problem solving, but contains itself a moment or phase of illumination. Another compound, the *Eureka experience* as used by Gruber (1981) refers to the subjective phenomenology. Gruber (1981, page 44) explicitly references the anecdote with Archimedes, but "reject[s] the idea, that sudden illuminations — 'Eureka experiences' — happen in a millisecond flash" which might have led him to use the term *experience* rather than *moment*. Rarely used in the contemporary literature, Lorge and Solomon (1955) have referred to puzzle-like problems as *Eureka-type problems*. In their study, Lorge and Solomon (1955) compare individual versus group performance in tasks like the Tower of Hanoi as well as rowing missionaries and cannibals across a river with only a small boat. The reference to *Eureka problems* arises when they discuss how solutions are found through a stage-wise model.

In addition to the terms already mentioned in table 2.1, *Eureka cry* is another example of a compound use of *Eureka*. Just like the *Eureka moment*, this term is directly derived from the original Greek story. Undoubtedly it was initially inspired by Pollio's (15/1914, Book IX, paragraph 10) text of Archimedes "crying with a loud voice that he had found what he was seeking". Besides the striking mental imagery, the term *Eureka cry* highlights the temporal facet of a little shout and the emotional aspect of a positive surprise (Koestler, 1964). In his book and when introducing the idea of *bisociation*, he equally used the terms *Eureka process* and *Eureka act*. Arguably these last two terms refer more to the process in which the *Eureka cry* and the *Eureka moment* are embedded. The almost synonymous use of the three terms in Koestler's (1964) book highlights an issue in the scientific literature: terms that potentially describe separate and dissimilar phenomena might be used interchangeably.

The term *Eureka* has been used for almost 2000 years in the literature to describe moments of sudden understanding. The term and the associated anecdote are intuitively understandable, grounded in everyday language and experience, and are similarly used across languages. *Eureka* acts as a conversation starter, but even a quick gaze at the dictionary and some of the scientific literature illustrates its ambiguous use, multiple meanings, and unclear definition. Intrigued by the phenomena behind these experiences, I am using the term *Eureka* when referring to the experiential aspects as summarised in definition 1. I will use the following sections to explain the phenomenon through related and sometimes alternative terms, to further narrow down what I am interested in.

2.2.2 Insight: a case for linguistics investigators

The word *insight* is frequently used in everyday language to describe that someone understands a causality within a given context or to gain "an accurate and deep understanding" ("Insight", 2018). The word is consequently used in the scientific literature across all disciplines, suggesting correct and profound findings. A technical term at least in Psychology and Psychiatry, *insight* has also one or more specific meanings there. In the literature related to creativity, innovation, and problem solving, many different and sometimes competing definitions have been offered. In this section, I trace back the history of the term and offer a novel view on the origin of the word for creativity research. Furthermore, I distinguish between existing definitions of *insight*.

In addition to having different meanings between disciplines, the term *insight* is ambiguous within the Cognitive Sciences. It is not only used to describe traits, abilities, and states; *insight* also describes them in an epistemological as well as a phenomenological sense (Kühle, 2015). For example, the moment a solution is found is called *insight*, but the found solution is called *insight* as well.

The scientific literature related to problem solving, creativity, and innovation often refers to Köhler (1925/1976) as the origin of the term *insight*

(Bautista, Roth, & Thom, 2011; Birch, 1945; Bowden, 1997; Bowden & Jung-Beeman, 2007; Clark, 2015; Danek et al., 2012; R. L. Dominowski, 1995; Epstein, Kirshnit, Lanza, & Rubin, 1984; Fioratou & Cowley, 2009; Fleck & Weisberg, 2004; Kaplan & Simon, 1990; Knoblich, Ohlsson, Haider, & Rhenius, 1999; Knoblich, Öllinger, & Spivey, 2005; Luo & Knoblich, 2007; Luo, Knoblich, & Lin, 2009; Ohlsson, 1984, 1992; WangBing Shen, Luo, Liu, & Yuan, 2012; Sternberg & Davidson, 1983; Weisberg, 2015). Interestingly I found a notable difference regarding the term *insight* between the original publication by Köhler (1921/1963) and the first translation, even though the "terminology used in this translation was agreed upon after detailed discussion between author and translator" (Köhler, 1925/1976, page vi). Here I will discuss these difference in more detail.

Reading the original German publication (Köhler, 1921/1963) and the first English translation (Köhler, 1925/1976) I came to notice that the term *insight* has been used differently. In the German original, Köhler (1921/1963, page 2) translates an English sentence by Thorndike (1911, page 75) literally as "Nothing in their behaviour ever seemed insightful"[1]. The original English sentence by Thorndike (1911, page 75) reads "I ...failed to find any act that even *seemed* due to reasoning" (italics in the original). The next sentence goes on "To someone who formulates his results like that, another behaviour must have appeared as insightful..."[2]. In the English version Köhler (1925/1976, page 3) states "To anyone who can formulate his results thus, other behaviour must have seemed to be intelligent". As the two examples illustrate, the Köhler uses the German word 'einsichtig' (English: 'insightful') as synonyms for 'intelligent' and 'reasoning'. In the translation to English four years later, the occurrences of 'Einsicht' (English: 'insight') is translated as 'intelligence' until in the first chapter, Köhler's (1921/1963, page 9) 'Einsicht' becomes 'insight' (Köhler, 1925/1976, page 13). Much later in the book, the translator explains this in a footnote: "The German word *Einsicht* is rendered by both "intelligence" and "insight" throughout this book. The lack of an adjective derived from

[1] Author's literal translation from the original: "Nichts an ihrem Verhalten erscheint jemals einsichtig"

[2] Author's literal translation from the original: "Wer seine Ergebnisse so formuliert, dem muß anderes Verhalten schon als einsichtig erschienen sein..."

the noun "insight," apart from other considerations, makes this procedure necessary" (Köhler, 1925/1976, page 219).

Köhler (1921/1963) supposedly used the term 'Einsicht' primarily as a matter of style and as a non-technical term approximately 90 times throughout the book. Nevertheless, he seems to have a technical term in mind as well since at one point he identifies a "criterion of insight: *the appearance of a complete solution with reference to the whole lay-out of the field*" (page 190 Köhler, 1925/1976, emphasis in original). This translation is consistent with the original text [3]. Since Köhler (1925/1976, page 190) explicitly refers to Selz, the use of the term might have been inspired by the wording used by Selz (1913, page 160)[4] to describe the *insight* into the structure of knowledge as a mean to comprehend the knowledge itself[5]. Conceptually this is building on earlier publications in which other names were used to describe the 'appearing thought' (Watt, 1906, Pt 3). This difficulty in translation could be found for many other terms, but it is beyond the discussion of this section.

In the year after Köhler's (1921/1963) original publication, Selz (1922) used the word *insight*[6] extensively and as a technical term, in particular, in the chapters where he expands on Köhler's (1921/1963) findings. Here he defines *insightful* as "the application of a solution method, as far as the circumstances, on which their application relies, acknowledge or abstract, and this finding the application entails"[7].

In Köhler's (1925/1976) English version of the book, published three years after Selz's (1922) response to Köhler's (1921/1963) German publication,

[3] Original: "Danach ist dieses Merkmal: Entstehen der Gesamtlösung in Rücksicht auf die Feldstruktur als Kriterium der Einsicht anzusetzen" (Köhler, 1921/1963, page 137)

[4] For a discussion of the relationship between Selz and Köhler see ter Hark (2010)

[5] Original: "Allein die Einsicht in die Struktur der auf diese Weise entstandenen Wissensdisposition ermöglicht uns gleichzeitig das Verständnis der Struktur der Wissensdisposition überhaupt"

[6] Original: *Einsicht*

[7] Author's literal translation of "Als einsichtig bezeichnen wir die Anwendung einer Lösungsmethode, soweit die Sachverhältnisse, auf denen ihre Anwendbarkeit beruht, erkannt, d.h. abstrahiert sind, und diese Erkenntnis die Anwendung bedingt" (Selz, 1922, page 591)

the use of insight appears different from the original. There is a quantitative difference between fewer uses of *insight* in the English version as compared to the German one. Not only occurrences of 'Einsicht' have been replaced by other words, but also the word *insight* has been used in places where it was not used in the original. In particular, one occasion seems important for the discussion of the meaning and the origin of the word: Köhler (1921/1963, page 140) writes about one of the problem solving approaches "and this coincidence ...immediately leads to 'comprehension'[8]". In the English translation instead, Köhler (1925/1976, page 194) states: "and the accident [...] led at once to "insight". Sentences like this, the translator's footnote later in the text, and the less than 30 distinct uses in the English translation seem to emphasise the importance of the term and might have given the impression that it was supposed to serve as a technical term. To some extent, this could be seen as the adaption of the technical term introduced by Selz (1922), and the attempt to establish it in the English literature. Unsurprisingly, and with no English translation of Selz (1922) available, early reactions to Köhler's (1925/1976) publication seemed to have interpreted *insight* as a distinct process or an enabler for understanding a solution.

Other authors went on to provide definitions of the term in English, and I will come back to this. A hint towards the confusion that surrounded the introduction of the term is apparent in a later text: Even more than twenty years later Köhler (1947, page 341) feels the need to clarify his understanding of the term. He writes "the direct awareness of determination [...] may also be called insight". In this publication, he previously introduced the idea of 'experienced determination' as the "dynamic relations between the self and certain objects". According to Koestler (1964, page 583), the 'experienced determination' is synonymous with the 'intrinsic connection' or the "between the attitude and its sensory basis". In any case, Köhler (1947) clearly rejects the idea of *insight* as a 'mental agent'. For other Gestalt Psychologists this seems clear. For example Maier (1931, page 337) in the attempt to define *insight* within the context of learning states that "insight may be defined as the experience an organism has when two or more iso-

[8] Author's literal translation from the original: "und jener Zufall scheint ...sofort zum 'Verstehen' [zu führen]."

lated experiences come together. Thus *insight* is the sudden experiencing of new relations." In a later publication, he emphasises the experiential part by stating "old familiar objects in new organizations become new things. This is a jolt, and gives us the experience we call insight." (Maier, 1937, page 375). Earlier in the same publication, he had discussed "at best [insight] can be regarded as an experience which accompanies problem solving in humans. As an experience, it is worthy of consideration even if it plays no causal role in the process" (Maier, 1937, page 373).

Following the trajectory of Köhler further, he later realises that early accounts of *insight* were misunderstood and not written very clearly in the first place. Another twelve years later, during his presidential address to the American Psychology Association, Köhler (1959, page 729) clarified: "What is insight? In its strict sense, the term refers to the fact that, when we are aware of a relation, of any relation, this relation is not experienced as a fact by itself, but rather as something that follows from the characteristics of the objects under consideration. [...] should this achievement be called *a solution by insight?*. No — it is by no means clear that it was also insight which made that particular relation *emerge*. [...] Consequently, it is misleading to call the whole process a 'solution by insight'." (*italics* in the original). This text echoes what his colleague Duncker had written the year after Köhler's (1925/1976) English publication. He defines "Due to insight ('einsichtig') is a phenomenal or physiological content in as much as its relevant traits are immediately, that is, without an intermediating third-factor, determined (suggested) by intrinsic traits of the stimulating content" (Duncker, 1926, page 701). Later Duncker identifies an ambiguity of the term and tries to resolve it by introducing "insight of the first degree" and "insight of the second degree" (Duncker, 1945, page 65). This suggests that the term was not yet settled in the 1940s.

Within the English speaking community Ruger (1910) reports "He was then given the puzzle and solved it at once. [...] Of course, there is no mechanical way for the production of insights". Hartmann (1931) also noted that the term was frequently used by Ruger in his lectures to distinguish between human and animal learning. A more general use was mentioned around the same time in the dictionary where *insight* was the "immediate cognition of an object; intuition [Rare]" ("insight", 1911). This is consistent with

Hartmann's (1931) mention that the term *insight* was not used before Köhler's (1925/1976) publication, but was quickly adapted afterwards even though the meaning was ambiguous. He ends with a list of questions that need to be addressed before a theory of *insight* could be developed. This ambiguity is also a topic for Bulbrook (1932), who lists 16 different meanings of the word *insight* and attempts to identify a distinct underlying process but ultimately fails in doing so.

Following this reading of the literature, I argue that *insight* entered the scientific literature from two distinct sources: in the Anglophone literature Ruger (1910) used it early on to describe ideas that were suddenly perceived in a non-analytical way. In German, Selz (1913) might have introduced the term to the Gestalt psychologists. Gestalt Psychology attempts to interpret how information is acquired employing the percept's reality, which is independent of the contributing parts. While the German version of Köhler's (1921/1963) seminal work uses 'Einsicht' in a mixture of everyday language and adoption of Selz's (1913) definition, the English translation uses *insight* quite differently and seemingly ambiguously. Nevertheless, the term made an impression and was widely used for different aspects and features across the field of Psychology in the early 1930s. This comparative review suggests that the term *insight* might have entered or been popularised as a technical term by the translation itself, and not necessarily as intended by Köhler (1925/1976). This ambiguity of the term was addressed several times in the 1930s and 1940s and seems to be retained in the current literature. However, the linguistic difference between the original work and the initial translation of Köhler's (1921/1963) book went previously unnoticed. I will revive this aspect in section 2.4 when I discuss contemporary components and theories in more detail. Consequently I contribute to the definition of the term *insight* through this analysis.

2.2.3 Aha

Supposedly Bühler coined the term *Aha experience*[9] in the German-speaking research community with his professorial dissertation in 1907[10]. One year later, Bühler (1908) published a study about understanding riddles. In this analysis of verbal protocols, he identified moments of surprise and comprehension. Bühler (1908) does not define *Aha* but suggests that *Aha* completes comprehension[11]. Furthermore, he asks, can a thought process be completed before it is understood[12]. Almost twenty years later on, Duncker (1926, page 661) defines *Aha* as the "sudden drop in the learning curve".

Duncker (1935/1963) uses the term *Aha* for the moment of sudden realisation and adds a new dimension to it by explicitly linking it to the reorganisation of thoughts. In section 2.4 I discuss temporal aspects and restructuring as markers of this moment, and in this context a small difference between the text written in his native language and the English translation might be of interest. The English translations mention that *Aha!* "are always and at the same time moments in which such a restructuring [...] takes place" (Duncker, 1945, page 29), highlighting the temporal connectivity between the moment solutions emerge and the restructuring. The original German text uses the word 'zugleich' which could be translated 'at the same time', but also as 'similarly'. Given that the German word 'zeitgleich' could be used for a temporal link and the rest of Duncker's sentence uses spatial ('wo') instead of temporal adverbs ('wenn'), it is at least possible that the English translation adds an emphasis on the temporal connection that is not in the original text. The preface written by his former colleague Wolfgang Köhler emphasises that Duncker "hated any compromise with vague terms" and that the translation was a

[9] orig: *Aha Erlebnis*

[10] I was not able to access this thesis to confirm.

[11] orig: "Eintritt des charakteristischen Aha, mit dem das Verstehen vollendet ist" (Bühler, 1908, page 17)

[12] orig: "Kann man sich denn denken, daß ein Gedanke zu Ende gedacht und dann erst verstanden wird? Das führt uns auf die allgemeinere Frage, was denn eigentlich vorgeht bis zum Eintritt des charakteristischen Aha, mit dem das Verstehen vollended ist." (Bühler, 1908, page 17)

difficult task (Duncker, 1945, page iv). This indirectly supports the idea that Duncker did not intend to write about the temporal link between *Aha* and restructuring thought. My primary interest in this project is in the moment solutions emerge, and not on restructuring as one of many potentially correlated features. Estimating the influence of this imprecise translation on later research, potentially overstating the importance of restructuring as a temporal marker for *Aha*, was therefore outside of the scope of this thesis.

Aha Erlebnis, *Aha moment* and *Aha experience* have been used in other languages since Bühler's (1908) text and are closely related to the *Eureka experience*. For example, both, the *Aha experience* and the *Eureka experience* emphasise the psychological aspects of the moment when ideas come into existence. This psychological aspect is highlighted in more recent publications. For example, Bowden (1997, page 545) states that a "characteristic of insight solutions [...] is the unique subjective experience of insight (the Eureka! or Aha! experience)". While this is a description rather than a definition, Bowden (1997, page 569) also states that "a satisfactory operational definition of the Aha! experience remains elusive". In his paper, Bowden (1997) mentions different aspects of *insight* which are further discussed in section 2.4 and uses *Aha* and *Eureka* synonymously. Other authors rely on *insight* in their definition of *Aha* as well, for example, Kaplan and Simon (1990, page 375) state that they "use insight to refer to a subjective AHA! experience during problem solving".

In his German textbook, Betsch, Funke, and Plessner (2011, page 163) argues that "the Aha Experience is a special case of insight and correlates with distinct brain activities"[13]. A similar definition was used by Kounios et al. (2008, page 282) for measuring brain activities related to *insight*. For them the *Aha! phenomenon* is "the sudden awareness of the solution to a problem" and the same as *insight*. In a later publication, Kounios and Beeman (2014, page 71) suggest that the *aha moment* is an *insight* within the context of problem solving, but not for understanding a joke, metaphor, or ambiguous concept. Indeed, Koestler (1981, page 7) had coined the term

[13] Authors translation from the original: "Das Aha-Erlebnis ist ein Sonderfall von Einsicht und geht mit ganz bestimmten Hirnaktivitäten einher"

haha reaction for understanding humour (and *ah reaction* to appreciate beauty) to distinguish between these aspects as well.

For Topolinski and Reber (2010a, page 402) an *Aha effect* is "the sudden appearance of a solution through insight". Here suddenness is attributed to the *Aha*, but not necessarily to the *insight*. This suggests that *Aha* might be a part of a longer *insight*. Earlier Gruber (1981, page 41) used sudden *insights* to define the *Aha Erlebnis*. Yet the definition "sudden moments of insight, dramatic reorganisation of [an] idea" emphasises the reorganisation of ideas as a defining factor. Yet another interpretation highlights the emotional or affective component: "One of the most distinctive components of an experience of insight is the *aha experience*. The *aha experience* has been used as a synonymous term for insight; it is generally described as sudden, accompanied by strong emotional arousal that may be either positive or negative" (Webb, Little, & Cropper, 2017, page 3). Even though they do not distinguish between the *creative product* and the *creative process*, Aziz-Zadeh, Kaplan, and Iacoboni (2009, page 908) use *Aha* and *insight* synonymously when they claim that "insight solutions [are] also commonly called *aha moments*". While *aha* is often associated with positive affect, Hill and Kemp (2016, page 2) coin the term *Uh-oh moment* for negative affect that could be "considered as an antonym to the Aha moment" and relates it to Homer Simpson's *D'oh* from a popular culture cartoon.

In the argument above, *Aha* and *insight* are strongly linked or even considered to be synonyms. In contrast, Danek and Wiley (2017, page 1) recently disconnect *Aha* and *insight* by suggesting that their results "cast some doubt on the assumption that the occurrence of an Aha! experience can serve as a definitive signal that a true insight has taken place". They suggest compounds of the *Aha! experience* when they conclude that "strong Aha! experiences are clearly, but not exclusively linked to correct solutions, and consist of three key components: joy of discovery, confidence in being correct and a feeling that the solution appears all at once" (Danek & Wiley, 2017, page 12). Interestingly, this links back to *insight*, and I will discuss these factors in more detail in section 2.4.

I have shown that part of the scientific literature uses either *Aha* and *insight* or *Aha* and *Eureka* as synonymous terms (Betsch et al., 2011; Bowden, 1997;

Gruber, 1981; Kounios & Beeman, 2014; Sprugnoli et al., 2017; Webb, Little, & Cropper, 2017). The use of *Aha* or *Eureka* appears to reflect cultural and personal preferences, or at most a difference between individual subjective experiences and historic subjective experience. If anything, and based on the original use, a distinction could be made between a first-person perspective for the *Aha* of Bühler's (1908) students and a third-person perspective for Pollio's (15/1914) *Eureka*. On the other hand, the difference between *Aha* and *insight* seems more profound: at the core, an *Aha* is the moment of comprehension and similar to how I discussed the *Eureka moment*. Depending on their perspective, authors add affective or temporal aspects to the *Aha*. Here, and similarly for *Eureka*, this facet is reflected in the second compound word, as for the affective *Aha experience* and *Aha effect*, or the temporal *Aha moment*. Yet within the 110 years of literature, I could not identify a coherent distinction from other phenomena and terms, nor a consistent use.

2.2.4 Hunch

A *hunch* is defined as "novel recombination of knowledge and information precipitated out of memory by clues to coherence" (Bowers, Regehr, Balthazard, & Parker, 1990, page 94). The difference to an *Aha*, according to these authors, is a continuity in the process leading up to the *hunch*, while an *Aha* is the result of a discontinuous, discrete, and surprising step. Both *hunch* and *Aha* are called *insight* by Bowers et al. (1990). They further suggest that subjective reports of a warmth rating and other self-reports are not an adequate measure to support the claim of a discrete switch in the cognitive process.

Brock (2015), in his discussion of the difference between *insight* and *intuition*, uses *hunch* as a synonym for a feeling, often a tacit or an unjustifiable one. He provides examples of scientists who had a feeling about what might be the solution before they found and proved the correct answer. His examples of hunches include Watson's idea of DNA as a double helix model. The distinction to *insight* is not very clear, even though the discussion by Brock (2015) suggests that *hunch* represents the affective dimension of *insight*.

Similarly, Simonton (2016) positions *hunches* on a dimension of certainty between *intuition* and *feeling of knowing*. This is comparable to the use Platt and Baker (1931) more than 80 years earlier when he quotes Wallas (1926) model as an example of how scientific research progresses. More specifically, Platt and Baker (1931, page 1973) explicitly state that "illumination [is] corresponding to our 'hunch"'. Platt and Baker (1931, page 1975) also provide a lengthy definition of a *hunch* as follows: "A scientific hunch is a unifying or clarifying idea which springs into consciousness suddenly as a solution to a problem in which we are intensely interested. In typical cases, it follows a long study but comes into consciousness at a time when we are not consciously working on the problem. A hunch springs from a wide knowledge of facts but is essentially a leap of the imagination, in that it goes beyond a mere necessary conclusion which any reasonable man must draw from the data at hand. It is a process of creative thought." In this case, a *hunch* builds on the *imagination* of the problem solver and is essentially described as a combination of previous knowledge. At one point in his text, Platt and Baker (1931, page 1975) admit "possibly Wallas' term 'illumination' is better than 'scientific hunch' since the former has no extraneous implications". This might have changed since the original publication, and I will discuss this in more detail in section 2.2.6 on the topic of *illumination*. Platt and Baker (1931) continue "If I were to coin a new word for it we should [...] go back to Archimedes' explanation and call it a 'eureka"'.

From the reading of the literature, the term *hunch* or *scientific hunch* seems to have enjoyed wider recognition in the early 20th century. With the publication of Wallas (1926) the term might have been replaced by *illumination*, and potentially some authors followed the suggestion of calling the observed phenomenon a *Eureka moment*. More recently, the usage of the term *hunch* is not consistent: a popular science book refers to 'Darwin's hunch' as his anecdotal *Eureka moment*, others use *hunch* to refer to the cognitive processes involved in restructuring problems, and others use it to highlight the affective dimension of *insight* (Bowers et al., 1990; Brock, 2015; Kuljian, 2017).

2.2.5 Epiphany

The word *epiphany* is based on the ancient Greek term for *manifestation* that described “a sort of luminosity through which the divine signifies its presence” (Paris, 1997, page 87). In later Christian interpretations, epiphany became a *striking appearance* of divine powers. This is in the tradition of older texts where *epiphany* is often described as a result of intervention from a third party or even through the divine (Pucci, 1994, for an analysis of Sophocles’ texts see). In fact, in literary texts, the word has primarily been used in a spiritual and supernatural context. For the Western culture, this is derived from the celebration of Christian miracles. These miracles include the visit of the three Magi and, particularly for Eastern Christians, the baptism of Jesus Christ (McDonald, 2007, page 91).

Besides the religious meaning, the dictionary provides a secular definition as “a moment of sudden and great revelation or realization” (“Epiphany”, 2018). This adoption shows some resemblance with definitions of *Eureka moments* and *Aha*, most notably the ones given by Anderson (2011) and Topolinski and Reber (2010a). The moment of *epiphany* seems to appear suddenly, and it leads to something new, to a revelation. While *Aha* and *Eureka* are depicted as surprising, the realisation in *epiphany* seems to be *great*. This needs a bit of unpacking.

The term *epiphany* has been used in different fields and McDonald (2007, page 91) traces the term through a different disciplines “including social theory, literary criticism, humanistic education, narrative psychology, clinical psychology, and gay and lesbian studies”. *Epiphanies* have been referred to in literature and the arts as the presentation of elements and ideas out-of-context. Examples are Marcel Duchamp’s *Fountain* or René Magritte’s *La trahison des images (The Treachery of Images)* (see fig. 2.1). In James Joyce’s ‘Dubliners’, a collection of short stories published in 1914, *epiphanies* are recurring metaphors (Bowen, 1982, page 106). They are described as surprising life-changing events, often perceived out of context but nevertheless as turning points in the stories. In scientific and casual narratives, an example of a prominent author who wrote about epiphanies is Sacks. In the preface to one of his books, he explicitly links *occasions* in poetry to Newton seeing an apple drop and Archimedes' *Eureka*, and he goes on that "every such occasion is a eureka or epiphany" Sacks (1994, page ix). As another example, Chen and Krajbich (2017, page 1) uses the term 'epiphany learning' to describe a computational model for the type of learning that humans describe as an "unexpected moment of insight". Similarly, Berkun (2010) uses *epiphany* synonymously with *Eureka experiences* and *insight*. Berkun (2010) stresses the importance of the preparation prior to the *epiphany*, and he draws on ancient mythologies as well as modern narratives such as the often repeated myth of Newton realising the universality of gravitation after seeing an apple fall.

Figure 2.1: Duchamp's *Fountain* (left) and René Magritte's *La trahison des images* (right) as examples for *epiphanies* in art

Epiphanies are described as the feeling at the end of the process of generating new knowledge or arriving at a new understanding. This is similar to how Bühler (1908) understood the *Aha*. This feeling is fulfilling but also surprising, as supposedly unconscious or subconscious processes contribute to the solution and their result, or even the moment of a solution, cannot be predicted. The solutions are also often the result of a lengthy and laborious process. McDonald (2007, page 97–100) identifies or rather suggests a number of characteristics for epiphanies, such as a epiphanies being preceded by some negative mental states, a sudden appearance or increased awareness of something that a person is previously blind to, which results in a personal and long-lasting transformation. For example Sacks

(2012) described his drug-induced experience of reading a book which inspired him to start writing about his observations of patient experiences. Specifically, he reported hearing a "very loud internal voice" that spoke to him. While he had been taking different hallucinogenic drugs for some time, this experience had a long-lasting effect on him. He started writing a number of books about his experiences, and he apparently stopped taking amphetamines after this.

The same idea of a life-changing event is behind the epiphany in talent recognition (Feist, 2014, page 66). According to him, *epiphanies* are also called *crystallising experiences* in the talent development literature. As there is little connection to cognitive processes and the exact moment when lives are changed through *epiphany*, I am refraining from discussing this body of literature in more detail.

Contrary to the previous definitions of *epiphany* as a discrete step at a given time, van Iterson (2017, page 21) takes a different position. Understanding *complete epiphanies* as multisensory experiences that include all five senses, he states "epiphany should be seen as a series of small steps – a series of creative synthesis". Van Iterson (2017) further suggests that *epiphany* is an intrinsically social enterprise and at the centre of three stages of the creative process, preceded by the preparation and followed by sense-making and communication. He also suggests four qualities of epiphanies, 1. the preparation leading up to it, 2. they can be positive or negative (disgust), 3. they can be tied to certain times in retrospection, and 4. they are inherently relational.

2.2.6 Illumination

Illumination is one of the stages mentioned in the classical *sequential model* of creativity as introduced by Wallas (1926, page 80, 93) when the 'happy idea' 'clicks'. For Liljedahl (2005) a *moment of illumination*, a *flash of insight*, and *AHA! experience* are synonyms. In his study of mathematical problem solving of undergraduate students, he uses these terms interchangeably to describe the moment when a solution is found. Similarly, R. W. Smith and Kounios (1996) introduce the moment when participants experience an *Aha* as *discrete illumination* but do not provide a further distinction. Similarly, Metcalfe and Wiebe (1987, page 238) refer to the literature of "restructuring, intuition, illumination, or insight" as if they were synonyms, and reports results from their experiment as either involving sudden illumination or not. More specifically Metcalfe (1986, page 288) concludes that "insight problems involve a sudden illumination". Earlier, Gruber (1981) had also used *illumination* and *Eureka experiences* synonymously.

Drawing on Wallas's (1926) sequential model of creativity and anecdotal accounts, Thrash and Elliot (2004, page 959) refer to *illumination* as "this epistemic event in which one comes to see better possibilities". Here *illumination* is the experience of something "deeply important". This definition shows great conceptual overlap with other concepts mentioned in this chapter, for example the affective aspects of *epiphany*, but no distinction from *insight*, *Aha*, or *Eureka*. More generally, McKerracher (2016) refers to *illumination* as a metaphor for creativity. Drawing on recent anecdotal reports, illumination is discussed as the transition between the metaphorically dark unconscious thoughts and conscious engagement. This transition would result in potentially seeing problems from a different point of view and new light.

Interesting is Ohlsson's (1992) use of *illumination* as a distinct technical term. According to his interpretation, *illumination* is the simultaneous recall of a problem previously set aside and the *full insight* into the solution. The change to this problem happens involuntarily and therefore without any deliberate effort to recall it. Despite anecdotal evidence from eminent scientists, Ohlsson (1992) concludes that *illumination* is virtually non-existing and should not be confused with *insight* and *incubation*.

2.2.7 Serendipity

Van Andel (1994, page 643) defines *serendipity* as "the art of making an 'unsought finding'" and goes on defining *finding* similar to creativity, as new and valuable – with the value being *true* for science, *useful* for technology, and *fascinating* for the arts. Similarly, van Iterson (2017, page 19) defines *serendipity* as "the unsought but valuable discovery of a solution to a given problem while looking for the answer for a different problem". The word itself goes back to a fairy tale about the princes of Sri Lanka, which was called *Serendip* with the Old Persian name. These princes travelled the world making discoveries they did not search for. The word serendipity was first used in an 18th-century letter but eventually and around the mid-20th century it spread from Medicine as an explanation of how penicillin was discovered to more common usage. Van Andel (1994) argues that abductive reasoning is the only form of logical inference that allows the generation of new knowledge and sees *serendipity* as a precursor of abduction. Van Andel (1994) describes 17 different patterns of *serendipity*, each supported by an example from the literature and all of them having an element of surprise in it. He also describes different appearances of surprise as a necessary element of *serendipity*, such as the positive *serendipity* where the correct abduction is drawn, negative *serendipity* followed by a wrong or incomplete abduction, and pseudo-*serendipity* when the intended invention or discovery happens in an unexpected way. While for pseudo-*serendipity* the process is surprising, for the other two appearances also the result itself is surprising and possibly even unintended. In a way, *serendipity* produces a solution or a finding before the question or problem is known. Following the argument of van Andel (1994), it is therefore rather a process of problem finding than problem solving. He stresses the point that only prepared minds are able to recognise these seemingly coincidental solutions, and he argues that in hindsight many occurrences of *serendipity* are rationalised and brought into a logical order, even though many discoveries and inventions might originate in serendipitous coincidences. In his conclusion, he denies that *serendipity* can be algorithmically understood by a computer, as it cannot operationalise improvisation and as soon as something is planned, it is not unforeseen anymore – and therefore cannot be *serendipity*. Arguably this argument is born from a rather computer-sceptical belief of the author[14].

Agreeing with van Andel's (1994) general definition, Boden (2004, page 234) defines *serendipity* as finding something valuable without having searched for it. She also draws on the notion of surprise and combinatorial creativity, but she explicitly sketches a computational process in which analogical

[14]Van Andel (1994, page 644) states *When our computer is master, we reach disaster faster*

pattern-matching surprisingly verifies a spontaneous result from pattern-completion.

A slightly different use can be seen in Holland (1998, page 13). Here the author claims that *serendipitous novelty* and emergent phenomena share similarities to an extent which makes it difficult to identify elements of emergence in systems.

2.2.8 Terminology in this thesis

In this section, I have identified and discussed seven different terms that are often used to describe aspects of the moment when solutions emerge: *Eureka*, *insight*, *Aha*, *hunch*, *epiphany*, *illumination*, and *serendipity*. The differences are subtle, and the descriptions and definitions used across the literature leave enough room for ambiguity, equivocation, and vagueness. Consequently the terminology in the literature on creativity, problem solving, insight, and related phenomena is not consistent. In the previous paragraphs I demonstrated these problems in a detailed analysis of the literature. Here I conclude on the use of terms within this thesis.

Aha and *Eureka* primarily seem to refer to moments in time or to the affective dimension of the actor or audience. *Illumination* refers to the process leading up to understanding the solution, possibly encapsulating *Aha* and *Eureka moments*. A *hunch* seems to be a historic name for a concept close to *illumination*, which was apparently used regularly in the context of scientific discoveries. Finally, *serendipity* is similar to an *insight*, but without the intention to find a solution from the *actors*' or problem solvers' side.

Insight is used in everyday language as well as academic language. Even within the formal academic writing, *insight* is ambiguous as it is used to describe any outstanding finding as well as cognitive processes and the products of these processes. Nevertheless and used as a technical term, *insight* seems to be the most generic and most widely adopted term. Potentially influenced by its unclear history, the current adaption in the scientific literature carries little more than the imprecise meaning known from everyday language. Furthermore, the term is vague in its demarcation from *illumination* and any of the other terms previously mentioned. Within scientific publications the use of *insight* is often an equivocation, interchangeably referring to the *actor*, *action*, *affordance*, *audience*, or the *artefact*. In this section, I presented evidence that the reason for the imprecision dates back to the original sources of *insight* when it was introduced to the academic language.

Without further definition, the term *insight* refers to nothing more than the vague idea of an emerging solution. Within the context of this thesis, this is desired, and *insight* and the other terms will consequently be used in the sense specified in the following definition 1. Addressing the ambiguity in literature, I contribute an explanation how different terms used for the phenomenon of interest are linked to each other.

Definition 1: Terminology

> When referring to the phenomenon of interest, I will use the term *insight* or refer to it as the moment when solutions emerge. I will use *Aha* and *Eureka* for experiential aspects and further specify it through a second compound. I will use *illumination* to describe the stage in Wallas (1926) model. I refrain from using *epiphany*, *serendipity*, and *hunch* which can be seen as a manifestation of a difficult solution out of context, finding an unsought solution, and a term not currently used in research respectively.

2.3 Related concepts

Some terms are often used in the context of *insight* but describe a different concept such as the following *intuition*, *Einstellung*, *inspiration*, and *imagination*. On the other hand, *Satori* and *Kenshō* might be conceptually related, but the field of study is too far removed from the discussion in this thesis. In this section I discriminate them from the topic of this work.

2.3.1 Intuition

The word *intuition* is used in everyday language as well as being a distinctive term in Cognitive Science. This section explores the concept stemming from the use in everyday life as well as the discussion in scientific contexts, in order to show its connection to *Eureka moments*.

According to Gregory (2004, page 485–486) *intuition* is "arriving at decisions or conclusions without explicit or conscious processes of reasoned thinking". The entry continues explaining that almost all human behaviour and judgement is intuitive as it is rarely based on formal terms and "steps as prescribed by logicians". Although declining in importance, the term also appears to be used to describe perceiving self-evident truths. Often described as 'seeing' the truth, this process might yield a time component. In general the broad and inclusive description provided in this psychological companion does not allow a distinction between *intuition* and other terms. Could it be that everyday language provides a better understanding of the concept described by the term *intuition*?

In British English, according to the Oxford English Dictionary, *intuition* is the "ability to understand something instinctively, without the need for conscious reasoning"; instinctively is "without conscious thought; by natural instinct"; finally, instinct is a "natural or intuitive way of acting or thinking" ("Instinct", 2018; "instinctively", 2018; "Intuition", 2018). Resolving this circular definition, intuition appears to be the ability to understand something without conscious thought or reasoning.

The US American Merriam-Webster dictionary describes intuition as "the power or faculty of attaining to direct knowledge or cognition without evident rational thought and inference". Interestingly, this dictionary also adds a time aspect to it by defining intuition as "immediate apprehension or cognition". In a third definition, the dictionary mentions an additional direct link to insight by calling it a "quick and ready insight" ("Intuition", 2018).

The MacMillan English Dictionary brings in emotions and affect as other dimensions by stating that *intuition* is "an ability to know or understand something through your feelings, rather than by considering facts or evidence" ("intuition", 2018).

The Cambridge Advanced Learner's Dictionary mentions a number of dimensions intuition can refer to, by defining intuition as "(knowledge from) an ability to understand or know something immediately based on your feelings rather than facts" ("Intuition", 2018).

Considering the commonalities of these definitions, intuition involves the "ability to know or understand something". It is also apparent that intuition can be used to either describe the process of retrieving knowledge, or to describe the product — the acquired understanding.

The usage of words such as *know* and *understand* implies correctness and therefore some process of verification. Even though it is not clear if verification can be seen as part of the intuition, or rather a timely and spatially detached activity, having access to the knowledge through intuition suggests that at least some kind of (unconscious) verification can be considered as part of the intuition. The terms *knowledge* and *understanding* also imply appropriateness, at least concerning the *something*. The reference of *something* to be understood or known gives the notion of a problem that is solved without any claims about the type or quality of the questions to be answered. The root or source for intuition appears as an unconscious thought in some definitions, as an emotion or even as an instinct in others. In any case, these origins conceptualise a root outside conscious access or manipulation, therefore the absence of consciousness while acquiring the knowledge is a commonality within the explored definitions of intuition. Also, the features discussed so far show a great overlap with *Eureka moments*, and in fact the term intuition has been used almost as a synonym of *insight*, for example by Metcalfe and Wiebe (1987).

More recently Brock (2015, page 2) argues that *insight* and *intuition* are in fact distinct phenomena. While an "insight is an explicit awareness of novel relations that arrive with apparent suddenness but with little conscious awareness of processing", he defines *intuitions* as "tacit hunches or feelings that come to mind with little conscious awareness of processing". One of the main differences is that people are aware of *insight*, but *intuition* seems to denote a less conscious and tacit experience. Besides, there is no mention of novelty as a criteria for *intuition* while it seems imperative for *insight*. Nevertheless, in both cases tacit and conscious thought interact leading up to the phenomenon.

The definitions of *intuition* also have a temporal dimension, by being described as the immediate and quick perception of knowledge. This timing can be understood in two different ways, either in absolute terms or as relative to other potential processes of gaining knowledge. If considered as an absolute measurement, then the distinctive feature of *immediate intuition* is that the solution is available the moment a given problem is perceived or (fully) understood. If measured with respect to perceiving the problem, this is clearly a different process from insight in creative problem solving as used by Metcalfe and Wiebe (1987): *intuition* is missing preparation and incubation before finding a solution. *Intuition*, in this case, is rather a way of retrieving memory, albeit phenomenologically different from an active search, in the sense that it does not provide conscious recall of the search process itself. Even though the *intuitive product* is disconnected from the observed problem, the *intuitive process* of getting to the solution is not consciously accessible.

If the quickness is meant in respect to understanding a problem however, then other phases of a potentially creative process have happened before the problem was understood; this type of *delayed intuition*, in comparison to the whole problem, shows some similarities with the restructuring process that happens during insights. Nevertheless, it implies a metacognitive unawareness of the problem as a whole. Another interpretation of the time component of *intuition* allows a comparison to other processes of arriving at a similar solution. *Intuition* is often used as a synonym for system–1 in dual-process theories, possibly going back to Bergson (1911, page 154) distinction between intellectual and intuitive modes of thinking. This theory was later popularly described by Kahneman (2012) and Usher, Russo, Weyers, Brauner, and Zakay (2011), who contrasted intuition with deliberation. Intuition is also described as parallel, holistic, and resulting in affective states. One of the properties of this system is conscious access to the results while their *operation (or stages)* remain inaccessible. Deliberation or system–2, on the other hand, is sequential and rule-based with access to the process. In this view, intuition includes the *intuitive process* and the *intuitive product*, it also accounts for *immediate* and *delayed intuition*. It is important to note that Usher et al. (2011) assumes the two systems not to be isolated from each other during the decision making process, but rather as interacting with one another.

Within the context of creative problem solving, *intuition* might also have a negative connotation. When people engage with a problem, they might form one or more intuitions about plausible solutions. This intuitive product is not necessarily a final and communicable item, but rather an initial approach to the problem solving process. In this the intuitive process shares some properties with the *Einstellung* described in section 2.3.2, but has a less rigorous definition. If this initial *intuitive product* is correct, or at least a step towards the correct solution, then *intuition* is potentially helpful in this case. If it remains the only unconscious part within the problem solving process, then people might perceive this *intuitive process* as a *Eureka moment*. Instead, if the *intuitive process* is leading the *train of thought* to an impasse and people get stuck, then the initial bias is actually difficult to overcome. Resolving this blockage will be possible either through a conscious and analytical process, or through another unconscious leap. The latter needs to be stronger to overcome the fixedness of the initial intuitive solution, and it is also later in the process and might therefore mask the memory of the initial intuition. When asked to report on *Eureka moments*, people will more likely remember this later cognitive leap.

Kenneth J. Gilhooly (2016) refers to the idea of *intuition*, but appears to be using it in two different ways, either as a synonym for *Aha-insight solutions* and later as a synonym to “unconscious, or intuitive processing” in his *unconscious work* theory. The former refers to the *intuitive product*, while the latter one can be understood as an *intuitive process*. In both cases the use of the term remains fuzzy as it does not explicitly contrast *immediate intuition* even though the processes described in Kenneth J. Gilhooly (2016) are relying on an incubation stage prior to finding the solution.

Another distinction is made by Dörfler and Ackermann (2012): Based on their literature review in the management field, they identify two types of intuition, the *intuitive judgement* and the *intuitive insight*. Intuitive judgement is described as a kind of decision taking, particularly under time pressure, and appears to be what most management literature refers to as intuition. They identify *intuitive insight* as a distinct process which is primarily observed in creative problem solving. While they acknowledge that *intuitive judgement* is part of creative processes, for example when deciding which solution to emphasise, they also mention that *intuitive insight* generates novel solutions.

This section attempts to provide a description of *intuition* and how it is used within this thesis. The process of how to come up with a solution, as well as the solution itself, can both be referred to as intuition and will be referenced either as *intuitive process* or *intuitive product*. Stemming from this, a distinction between *intuitive insight* and *intuitive judgement* is also useful, particularly within the domain of creative problem solving. Time is another dimension to be considered, and a distinction has been made between *immediate intuition* and *delayed intuition*. Furthermore, it has been noted that intuitions can be wrong, even though the solution appears to be *correct* in the subjective evaluation during the process. These different dimensions of intuition will help clarifying and distinguish the Eureka moment as a unique entity throughout this thesis.

2.3.2 Einstellung

Einstellung is "the habituation to the repeatedly used procedure" as described by Luchins (1942, page 3). In his paper he shows experimentally that people are biased towards a certain way of approaching a problem by their previous experience in comparable or perceived similar situations. Therefore it appears that Einstellung is formed during or through previous problems, and is accessible as early as people engage with a problem. In fact it appears to influence the type of engagement from the beginning. Luchins (1942, page 3) also refers to an even earlier definition by Warren (1934) which apparently states that Einstellung is "the set which immediately predisposes an organism to one type of motor or conscious act". This definition does not just include the temporary dimension, but also makes a reference to the conscious act, which implies that the Einstellung is outside the conscious access.

More contemporary definitions describe Einstellung as a "temporary attitude, expectation, or state of readiness, especially in relation to a stimulus that is about to be experienced" (Colman, 2015). This definition stresses the temporal aspects by stating that Einstellung is a state of mind before people engage with a stimulus or problem, but it also highlights a connection between the Einstellung and the stimulus. In a repeated experiment with similar stimuli the connection is obvious and the origin of the Einstellung effect can be explained through the previous iterations of the trial, but for the initial engagement with a type of tasks there might be an attitude and expectation towards the stimulus, but since there is no explicit relation, this predisposition appears to be random or unexplainable at best. As a result the intuition might have a stronger influence in this case.

Bilalić, McLeod, and Gobet (2008) explore the connection between Einstellung and problem solving by giving chess tasks to players of different proficiencies. They reduce the Einstellung effect to the "negative impact of previous knowledge" and make a theoretical distinction between the influence of Einstellung on expert and non-expert performance (Bilalić et al., 2008, page 653). Through their experiments they show that people are fixated on a certain set of potential solutions which also blocks them from achieving better results, which is particularly interesting for self-reports: participants report to be working on something else. In this case the Einstellung effect has been demonstrated to work outside the conscious access of participants in the experiment.

2.3.3 Inspiration

Inspiration is a concept used across disciplines and conceptualised by Thrash and Elliot (2003) as implying *motivation*, being *evoked*, and involving *transcendence*. The motivation appears to be a directed process to pursue an outcome, in most cases towards a positive result rather than to disprove an existing idea. As suggested by the Thrash and Elliot (2003) this directed process is initially not steered by a conscious process. Instead inspiration can be evoked by external environmental sources or by unconscious *intrapsychic sources*, in both cases suggesting little control over the process and its direction. And finally the transcendence reveals novel and more appropriate ideas or potential to the people being inspired. Supported by these conceptualizations, Belzak, Thrash, Sim, and Wadsworth (2017, page 118) describes inspiration as an “episode that unfolds across time”, emphasising the temporal aspects of inspiration. Thrash and Elliot (2003, page 871) show that this is in compliance with definitions from dictionaries and a body of literature from the domains of “psychology, anthropology, theology, education, art and literature, management, and engineering”. They suggest viewing inspiration as a process, a *trigger* object evoking this process, and a *target* towards which the process is directed. This notion is extended by a component analysis of inspiration in Thrash and Elliot (2004), concluding that the directional inspiration can either be triggered *by* something or aiming *at* a target.

Other authors stress the importance of triggers as well, for example Malinin (2015) provides examples from individuals with great creative achievements such as contemporary painters, Rudyard Kipling, and Immanuel Kant. Triggers in this case include architectural elements, pieces of furniture, writing equipment, music, and views. From the perspective of creative cognition, an exploration of realistic ideas with creative potential and creative ideas targeting real problems is based on *inspirational qualities* of ideas (Finke, 1995, page 304–305). These qualities *excite the imagination and lead to meaningful explorations* and this whole process of *imaginative divergence* plays a role in distinguishing between appropriate and unrealistic ideas.

Finke (1995) places inspiration within a sequence followed by imagination and exploration. More general, time plays an important role in inspiration, from the moment the inspirational trigger is perceived, throughout the whole process of being inspired, until the moment the target is understood. Interestingly for the context of this work, Thrash and Elliot (2003) also mention an explicit connection to the Eureka moments by relating the evocation to the unconscious processes throughout the incubation stage, leading up to the illumination phase described by Wallas (1926). On the other hand Thrash and Elliot (2003) claim that the unconscious stages in sequential models neglect the idea of energisation through inspiration. Thrash and Elliot (2003) suggest that autobiographical memories of *feverishly* working on solutions are contrasted by the stage theories as incubation can not, at least not consciously, be energised. A solution to the apparent conflict offered by Thrash and Elliot (2003) by conceptualising inspiration as a motivational state, triggered by illumination targeted towards the realisation of the idea. Within Wallas's (1926) model, inspiration would then be situated within the verification stage.

The contextualisation of inspiration in relation to insight is ambiguous and depends on the interpretation of any of these terms. Specifically and considering the temporal localisation of inspiration as a state, Thrash and Elliot (2003) situates it within the verification phase, but also draw a connection to the incubation phase. Considering the motivational aspects often reported to follow an inspiration, it can just as well be situated early within a creative process. Consequently, I could not identify a direct connection between existing literature on inspiration and the temporal localisation in relation to the emergent solution within the creative process.

2.3.4 Imagination

According to Gregory (2004, page 443) *imagination* has a number of different meanings in everyday language, including states of mind of fluidity of thoughts, daydreaming, and novelty generation. The entry explicitly mentions the anecdote of the chemist Dmitri Ivanovich Mendeleev dreaming up the Periodic Table in an *intuitive 'leap in the dark'* after attempting to solve the problem of organising the chemical elements through analytical approaches for a long time. The same anecdote has also been coined as an example of insight in different other occasions (Cunningham, MacGregor, Gibb, & Haar, 2009). In the discussion of imagination in the psychological theory, Gregory (2004) emphasise the difficulty to measure imagination in behaviouristic experiments, and see it as a 'primary process thinking' from a psychodynamic perspective. The author concludes that imagination has not been identified and defined within the psychological theory.

Nevertheless Gregory (2004) identifies five components of imagination: mental imagery as the capacity to see or hear things with *the mind's eye and ear*, counterfactual thinking as the capacity to think about events disengaged from reality, symbolic representations of using images and entities to evoke others, cognitive fluidity to operate these representations, and emotions as facilitators. In the discussion of cognitive fluidity Gregory (2004, page 444) raises the question of how imagination differs from creativity. One possible answer considers imagination as a universal human attribute, while creativity is reserved to a small number of exceptional and talented people, thus marking imagination as *small* creativity. The other option offered by Gregory (2004) is that imagination and creativity are indistinguishable. The entry continues to differentiate through the outputs: while imagination is confined to the individual experience, creative output has the potential to being shared with other people. Finally the definition continues into a recollection of the sequential model of problem solving as an example of what is happening during imagination, providing Martindale (2009) as a source for these claims. The fact that Martindale (2009) does not refer to imagination, but exclusively to creativity, is not so much intended to discuss the quality of the entry in Gregory (2004) but should rather illustrated the difficulty of keeping imagination and creativity apart as two distinct concepts.

2.3.5 Satori and Kenshō

In this section I refer to a few concepts relating to insight in Zen Buddhism. Zen is chosen as an example for spiritual Buddhist enlightenment following from the practice of dhyāna because of the accessibility from a Western perspective, not only for the number of available translations but also for its popularity in the popular culture (Watts, 1958). Other forms of Buddhism seem to be following similar ideas, even though subtle ideas and differences might not be reflected in this section. All three schools of Buddhism — Theravada, Vajrayāna, and Mahāyāna — relate to spiritual insight. The example chosen for this section is Zen from the Mahāyāna school since it has an active community in the Western world, which also provides accessible documentation. Other Buddhist schools seem to refer to similar concepts as the awakening to the true nature of things (bodhi), which is one of the central ideas of Buddhism. Other religions have related spiritual concepts and practices, in particular the Vedic religion and Hinduism.

Satori is the Japanese term used in Zen Buddhism for *awakening* in the sense of *understanding*, and it refers to the experience of Kenshō. Kenshō consists of the terms *seeing* and *nature* and describes initial insights in the Zen tradition. In this case the nature in Kenshō relates to one's own Buddha nature; therefore, the whole term relates to series of realisations, all of which reveal the same knowledge and therefore the *true* character to different degrees of clarity. Originally, Kenshō referred to the non-duality of observer and observed, but the influence of Western culture transformed the term into a more experiential understanding (for an example see Low & Purser, 2012). While Zen-texts rarely refer to Kenshō as an experience, personal accounts of Zen practitioners describe individual occurrences which are often taken into account for translations into Western languages. Satori and Kenshō are often used interchangeably, but Kensho can also be used for brief glimpses on the nature, while Satori can refer to a longer lasting realisation. The *final enlightenment* Daigo-tettei, on the other hand, is an absolute experience that contrasts with the temporary realisations of Satori and Kenshō.

The Zen literature provides two different approaches to Kenshō, even though the amount to which they differ has been debated for a long time. Kenshō can be approached gradually through training and teaching, or it can appear spontaneously. The gradual approach is through studying so-called Kōan, short stories or statements that pose unanswered questions or ambiguous meanings. In Western culture these Kōan are sometimes understood or translated as *meaningless statements* or *riddles*, although Zen scholars oppose this view. Different curricula of Kōans are used to guide the students to realise their own self, in order to approach Kenshō gradually. These sets of phrases include a *hossi*, which has the function of triggering and verifying the breakthrough in thinking — the kenshō. For example, Low and Purser (2012, page 348) has explicitly stated that kenshō "is very similar to the 'Aha! phenomenon' or 'Eureka moment'". Teachers can also probe their students by asking *sassho*, the so-called checking questions. The answers to these questions inform the teachers on how far the *Satori* has progressed; they are also supposed to help students deepen their insight. Besides the gradual approach, spontaneous insights are well known in Zen literature. This sudden enlightenment, generally known as subitism, is also related to the term mushi-dokugo, which literally means *without teacher independently enlightened*. The last character in this term is the same as in Satori.

The Buddhist tradition of enlightenment is interesting for the study of insight, because it differentiates between types of gradual and sudden enlightenment. This is reflected in the discussion of gradualism versus subitism. It also emphasises the possibility of teaching the unteachable through the practice of kōan, by inducing *great doubt* in the student. In Buddhism there is also a way of checking if students have reached the state of enlightenment, even though the practice is highly dependent on subjective evaluations from the teacher. Finally, Buddhism emphasises that insight is only the first step, and that enlightenment requires repeated practice. In Buddhism, enlightenment originates within the practitioner and it is not induced by some external force. At the same time, it is a social practice, as it requires in-depth partnership between the teacher acting as a proxy to their lineage of teachers, and the student.

2.3.6 Divinity

In our modern world, the idea of a divine illumination seems to be antiquated if not a remnant containing a mix of ancient story telling, religious fabrications, and exaggerated self-appraisal. Going back to Socrates who claimed to have a voice "[turning him] away from something [he is] about to do", he was considered *worthy* of having a divine or spiritual cognitive guidance (Pasnau, 2015). Later philosophers and influential thinkers across different cultures and religions either based their trustworthiness on claims of external *divine* sources or were later attributed to have had support from the spiritual world in their decisions and idea generation. Within the Christian narrative the early theologian Augustine wrote "The mind needs to be enlightened by light from outside itself, so that it can participate in truth, because it is not itself the nature of truth." (cited after Pasnau, 2015).

In his speech addressing Goethe's presentiment of future ideas in natural science, von Helmholtz (1892) talks about the *apperception* or *beholding* (orig: *Anschauung*) of artists and scientists. While the term creativity (or *Kreativität*) was not commonly used by the time in any Western language (see Weiner, 2000), von Helmholtz follows Kant in using the term in a similar sense. Focusing on the example of poetic writing, von Helmholtz (1892, page 348) describes the spark of an idea also as *wit* (orig: *Witz*) and something that is "always a sudden insight, not reachable through reasoning, but like a sudden joy". He reasons that therefore the term for poet and seer are identical in Latin and he connects the sudden insight to the term of *Divination, a kind of divine inspiration*[15]. The whole speech in honour of Goethe's contribution to science draws connections between artistic work and scientific discoveries within the process of generating novel and appropriate contributions.

Interesting by itself, it becomes even more compelling in the light of a speech Helmholtz gave for his 70th birthday. Throughout his life as a researcher he had been interested in his own process of creation. An acknowledged and productive scientist by the time, von Helmholtz (1896) used the speech at his birthday to reflect on it and share some of his thoughts with colleagues and friends. Even though he reports to have preferred work that can be solved through reasoning and does not rely on *fortunate accidents* and *insights*, he acknowledges that many inventions and discoveries relied on lucky incidents, some of them appearing suddenly and without effort. Other solutions were *silently* perceived without acknowledging their usefulness, but then through processing without conscious involvement, they suddenly appeared. Before this incubation phase and the potential

[15]The original passage reads: *Das Vermögen, bisher ungeahnte Aehnlichkeiten zu entdecken, nennen wir Witz. Unsere Altvordern brauchten dieses Wort auch im ernsten Sinne. Immer bezeichnet es eine plötzlich auftauchende Einsicht, die man nicht methodisch durch Nachdenken erreichen kann, sondern die wie ein plötzliches Glück erscheint. In ältester lateinischer Bezeichnung ist deshalb der Name des Dichters mit dem des Sehers identisch. Die plötzlich auftauchende Einsicht wird als Divination, als eine Art göttlicher Eingebung bezeichnet.* (von Helmholtz, 1892, page 348)

illumination, he mentions that he *always* had to observe the problem from all possible perspectives, he had to prepare his mind and memory for the problem. He assumes that this preparation phase allowed a high processing fluency later in the process which in return contributed to finding the solution. Helmholtz reports also prerequisites that he observed in his own problem solving approaches, for example not being tired, away from the desk, and not having consumed alcohol (von Helmholtz, 1896, page 15–16). In his reflection on his own creative process, he still has the idea that scientists and artists who have more ideas are favoured by some entity he calls *nature*, but which seems to have divine attributes.

The two different speeches delivered by Helmholtz appear to be be grounded in the idea of external cognitive processes and divine illumination (von Helmholtz, 1892, 1896). Thirty years later the three stages of creative problem solving are extended by a fourth one and popularized in the English literature (Wallas, 1926). The terminology used in this influential book draws on the early mythological ideas of creativity.

2.3.7 Psychiatry

The psychiatric use of *insight* is prominently mentioned in the dictionary as the "awareness by a mentally ill person that their mental experiences are not based in external reality" ("Insight", 2018). On a side note, Nęcka's (1999/2011, page 667) prototypical definition of insight as "a sudden realization of the essence of a complex, paradoxical, or not well-understood situation, particularly the essence of a problem at hand" seems almost contrary. In this case, *insight* connects the internal problem solvers' representation with a potentially externally defined problem. At the same time, it could be argued that insight is the realisation of the internal representation not matching the (external) problem (overcoming the impasse or breaking through).

Sometimes the boundaries between different meanings of insight are not quite clear, for example Friston et al. (2017) references Dresler et al. (2015) as a supposed review on the neural correlates between insight in different mental states, even though the latter refer to insight in the psychiatric meaning of gaining insight into the mental illness.

2.4 Operationalisation

The moment when solutions emerge is an intangible concept and, judging by the loose terminology illustrated in section 2.2, difficult to grasp through the terminology adapted in the scientific literature. In this section I am discussing existing attempts to operationalise the underlying concept. I start with existing theories for how *insight* come into existence before I discuss different aspects, components, and dimensions of the phenomenon.

2.4.1 Theories for the phenomenon

Several theories to explain *insight* have been proposed in the literature. Here I introduce five commonly used theories, namely the *representational change theory*, the *progress-monitoring theory*, the *three-process theory*, *bisociation*, and the *impasse-insight sequence*.

Two different variants of the 'representational change theory' have been proposed over the years. In both cases, people hit an impasse while attempting to solve a problem. An incomplete internal representation of the problem is the reason for experiencing the impasse according to Kaplan and Simon (1990). Alternatively, the prospective problem solvers might put too many constraints on a task (Knoblich et al., 1999; Knoblich, Ohlsson, & Raney, 2001). Through two different processes, constraint relaxation and chunk decomposition, a change of activation across the working memory leads to a sudden experience of understanding the solution. Breaking out of the initial and inappropriate representation of the problem is the *moment of insight*. Part of Knoblich, Ohlsson, Haider, and Rhenius's (1999) discussion around *insight* and breaking impasses referred to the participants' knowledge and was touching on individual differences.

In the progress-monitoring heuristics introduced by MacGregor, Ormerod, and Chronicle (2001), impasses play an important role as well. In this theory, people perceive the distance from their current solution to the anticipated goal state. If their current solution path is blocked by an impasse, they attempt to solve it through another route and experience an insight. Particularly, MacGregor et al. (2001, page 176) defines insight as "the recognition or restructuring of a key feature of a problem that allows a solution to be found". According to this theory, and tested further by Chronicle, MacGregor, and Ormerod (2004), there can be more than one *insight* involved in solving a problem.

Sternberg and Davidson (1983, page 53) suggest a three-process theory of *insight* which consists of selective encoding, selective combination, and selective comparison. It is their attempt to provide a testable theory to the descriptions they have extracted from the Gestalt literature, such as "short-circuit of normal reasoning" and "unconscious leap in thinking". In their theory, people distinguish between relevant and irrelevant information during the selective encoding. During the selective combination, previously unconnected and isolated information are united. A comparison between new and previously acquired information is done during the selective comparison. In a later study, Davidson and Sternberg (1984) supports this theory with empirical data.

Koestler (1964, page 45) contrasts rational thinking with dream-like states and "escape[s] in the opposite direction", the "spontaneous flash of insight which shows a familiar situation or event in a new light, and elicits a new response to it". In his idea of 'bisociation', the ability to change between different planes of existence and switch between two of them at the same time, a dream would be situated on a more primitive plane. During an insight, on the other hand, a person would change to a more complex level.

Ohlsson (1992) introduces the term *impasse-insight sequence* to provide a theory of *insights*. In Ohlsson's (1992) text, *insight* means breaking an impasse. Based on his reading of the previously existing literature, Ohlsson (1992, page 5) suggests that *insight* is "initial failure followed by eventual success”. Not every failure or impasse necessarily leads to an insight. Instead, Ohlsson emphasises that the problem solver needs to be competent to find the solution. He also distinguishes between two different types of *insights* following Koffka’s (1936, page 641) terminology: *partial insight* for overcoming an impasse but not quite solving a problem, and *full insight* for breaking an impasse and solving a problem. At one point, when explaining a case study, Koffka (1936, page 631) writes: “In this case, one single step would have led to insight, whereas the other possibilities would have required two or more steps for its development, although each step in itself would have been a case of partial insight. Therefore insightful behaviour is not necessarily a behaviour in which the full solution occurs at once.” In their proposed theory, Ohlsson (1992, page 6) addresses three questions: 1. “Why do people encounter impasses for problems they are competent to solve?” 2. “How are impasses broken?” and 3. “what happens after the impasse is broken?”. Referring to the language of information processing, he suggests that impasses are encountered if the initial encoding or structure of the problem does not activate the operator needed to solve the problem. They are overcome by adding more information to the problem, here called *elaboration*, by re-encoding the problem, or by relaxing the constraints on the sought solution. Contrary to previous theories that people gain access to a previously and unconsciously constructed solution during the moment of insight, Ohlsson (1992, page 17) hypothesises that the solution is constructed in this moment and the perceived appearance is an illusion, due to the lack of introspection of the problem solver. Furthermore, according to this theory, the difference between *partial insight* and *full insight* depends on the distance of the broken impasse to the solution.

2.4.2 The processes of insight

Insight is often contrasted with analysis as another approach to solve complex or difficult problems. Aziz-Zadeh et al. (2009) also highlight memory retrieval as a third potential alternative to finding a solution, and they argue, that this is fundamentally different from *insight* as well as analytical processes.

In the literature two fundamentally different ideas are known regarding the underlying cognitive processes related to insight phenomena. They are referred to as the *Special-Process* and the *Business-as-usual*. In section 2.2.2 I mentioned, that, even though he reportedly did not subscribe to that idea, Köhler's (1925/1976) book was interpreted by others as if *insight* was a distinct process. R. L. Dominowski (1981, page 194) argues that Gestalt psychologists "view insight not as an exotic precursor of problem solving but as a possible accompaniment to problem solving". This is emphasised by Ellen (1982) as well, opposing other views that claim Gestalt psychologists had identified *insight* as a process. Instead, Ellen reiterates that the process might be similar to what is experienced during the figure-ground reversal.

Nevertheless the *Special-Process* theory plays an important role in the contemporary literature. For example, it is the underlying assumption for current neuroimaging studies, some of which aim at identifying neural correlates to the *insight* process (Dietrich & Kanso, 2010; Jung-Beeman et al., 2004; Kounios & Beeman, 2014; Sandkühler & Bhattacharya, 2008; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009). Others develop theories that rely on special processes or extrodinary observations (Knoblich et al., 1999; Ohlsson, 2011).

In the *Business-as-usual* camp, D. N. Perkins (1981) discusses well known anecdotes such as Poincaré's development of the Fuchsian function and Kekulé's discovery of the benzene ring in the context of *special-process* theories published at this time. He concludes, that all the anecdotes can be explained without the need for a special *insight* process.

Similarly, Sternberg and Davidson (1983) reject the special-process theory of *insight* and hypothesises that insight consist of three testable psychological processes: *selective coding*, *selective combination*, and *selective comparison*. At the same time, they warn against the conclusion that there is no special cognitive process on the basis that it cannot be measured with current instruments. They conclude that giftedness as a personal trait might be related to an *insight skill*.

For a car-parking puzzle, G. Jones (2003) demonstrates that participants in this study accompany analytical approaches with occasional insights.

Weisberg (2015) formalises this into a *integrated theory*, building on aspects og the *business-as-usual* and the *special-process* theories.

Independent of the discussion between these two camps and regarding the dynamics of insight, Wallace (1991, page 48) suggests that *insight* is not a momentary flash. Instead she refers to as a "microgenetic developmental process". She argues that an investigation of insights as process rather than a moment could afford new results for the phases of the creative process preceding and following the *insight moment*. A few years earlier, Gruber (1981, page 54) had already challenged the view, that insights can be reduced to or understood as moments. Drawing on the examples from Archimedes and Poincaré, he suggested that a "continuously working, evolving system of thought [...] produces important insights from time to time". Currently, most studies assume *insight* to be dichotomous, they either happen or not (Bowden & Jung-Beeman, 2003; Kenneth J. Gilhooly & Murphy, 2005; Hedne, Norman, & Metcalfe, 2016). In other studies different types of self-reports have been used to assess the intensity of the *Eureka experience*. For example, Bowden and Jung-Beeman (2007) asked participants to choose on a five item Likert scale between 'strong non-insight', 'neutral', and strong insight. Other studies asked participants to report the strength by adjusting the brightness of a lightbulb (MacGregor & Cunningham, 2008), or rate how surprising their *Aha experience* was (Danek, Fraps, von Müller, Grothe, & Öllinger, 2014a) on scales between 0 and 100. Following from the discussion in this paragraph and the gradual experience of Satori mentioned in section 2.3.5 I wonder, if the more differential view provides a better description of the phenomena. Chapter 4 provides empirical support for this theory.

2.4.3 Numerous features of insight

Authors often describe or define *insights* through associated phenomena. They are used to test theories, verify tasks, and compare individual performances, yet there is no overarching agreement within the literature on the number or type of features. This section provides some examples, without the claim of completeness.

Newell, Shaw, and Simon (1958) use two components to define insight. Referring to “the psychological literature” they name suddenness of discovery and grasp of the structure of a problem to contrast insights against trial-and-error behaviour. The two features of *insight* identified by Schooler, Ohlsson, and Brooks (1993) are different. They see the surprise or unexpectedness of the solution and overcoming an impasse as the defining phenomena. Ansburg and Dominowski (2000, page 31), in the tradition of Gestalt theorists, suggests restructuring as the underlying cognitive process for *insight*. The sudden awareness of a solution is an *insight* or *Aha! phenomenon* for Kounios et al. (2008, page 282). They also add that people have “little or no access to the processing leading up to that solution”. In an attempt to map the emotional correlates of *insight*, Wangbing Shen, Yuan, Liu, and Luo (2015) explore 98 different emotional states on psychological and motivational dimensions. Results from their study show that people associate *Aha experiences* with positive affect and certainty.

On the other hand, three aspects are named by Bowden, Jung-Beeman, Fleck, and Kounios (2005) as defining features of *insight*. In their work on developing the compound remote associates, they assume that *insight* refers to clear understanding of a solution, its sudden realisation, and is thought to happen after breaking free from previous assumptions. Similarly, Chein and Weisberg (2013) name the feeling of knowing, suddenness, and overcoming an impasse as markers for *insight*. Instead, Wallace (1991) identifies three different features of *insight*, called facets in her work. They are the organisational, the developmental, and the modality. In her description, the organisational facet is responsible for the reorganisation and restructuring of existing thoughts. Secondly, the developmental facet describes the process and is often experienced as a sudden flash of insight. In her paper, Wallace (1991) discusses the rapid succession of different stages within a single instance of insight on the example of two literary insights but explicitly suggests that the same applies to scientific insight. Finally, in the modality facet, she raises the question how unimodality or multimodality influence the other facets. Bowden (1997) also identifies three different features of insight: the experience of an impasse, the affective dimension of an *Aha* experience, and the inability to report on the processes leading to a solution. Instead, the three approaches Chronicle et al. (2004) identify to define insight problems are through phenomenology, through the required conceptual change, or through the involved processes. They suggest that a restructuring of the initial problem representation is common across all of these three approaches and therefore they identify restructuring as the *insight*. According to Chronicle et al. (2004), the difference to traditional Gestalt theory is that an *insight* can be the result of a solution and is not necessarily happening before finding an answer to a problem. Ovington, Saliba, and Goldring (2016) also mention three features for the moment of insight: the solution arrives suddenly, it is complete, and people have the feeling that the solution is correct. For the development of their self-reported scale, they provide a definition to their participants that *insight* happens suddenly and unexpectedly. In a more recent publication Ovington, Saliba, and Goldring (2017, page 585) reduce the definition of *insight* to "the moment a solution to an unsolved problem suddenly pops into consciousness". In this case, they mention *Aha* as an affective response to the suddenness of the solution.

R. L. Dominowski (1995, page 75) gives an overview of the commonalities and differences between the understanding of *insight* by some of Gestalt's most influential thinkers. He goes on by also identifying three features that insight problems seem to share: "no specialized knowledge is required [...], some form of new response is required, [...and] a change in view of the problem" is required. He further acknowledges that a problem can only be considered as insightful for typical problem solvers at most, not for everyone. Referring to the psychology of breakthrough thinking, D. Perkins (2001) mentions three aspects necessary for insight: active knowledge, pattern priming, and breaking mental sets. He emphasises that the knowledge necessary to solve a problem does not only need to exist, but it also needs to be accessible by the time it is required. Pattern priming is a readiness for the problems, something D. Perkins (2001, page 223) calls 'mental watchdogs that are likely to bark when a relevant clue comes along'. This priming would provide an explanation for how people come back to a problem they have worked on before and while trying to solve another one. Finally, the mental set describes some fixedness on a promising solution. This needs to be broken if it leads to an impasse.

Gathering different interpretations of the phenomenon, Öllinger and

Knoblich (2009, page 276) suggest that the existing definitions of *insight* vary on three different dimensions: task, phenomenology, and process. For the task dimension Webb, Little, and Cropper (2016), who use the same distinctive dimensions, discusses the problem space and extension thereof as a potential feature of insightful problems. Both publications list examples and compare it to non-insight problems, but suggest that there is no definition for insightful problems. The phenomenology is discussed within the features of the *Aha experience*, suddenness, confidence, and other subjective experiences. The process dimension discusses the assumption of a sudden switch or restructuring of the problem. Öllinger and Knoblich (2009) relate this mainly to impasses, while Webb et al. (2016) emphasise that people have no recollection or access to the steps in the insightful process, while they are able to recall analytical processes. Hedne, Norman, and Metcalfe's (2016) study on magic tricks, problems solved via *insight* were rated with higher confidence than problems solved without *insight*. Previously Danek, Fraps, von Müller, Grothe, and Öllinger (2014b) had assessed a higher confidence rating for *insight solutions* as well, but they had used confidence in the definition of insight given to the participants, so this could have been a potential confound in their results. Hedne et al. (2016) also explicitly link confidence with the correctness of the solution, and Steele, Johnson, and Medeiros (2018) highlight that confidence predicts a creative outcome. Further support for the link between confidence, correctness, and *insight* comes from Topolinski and Reber (2010b), who identified a higher probability to be correct for insight solutions in anagram tasks. Chein and Weisberg (2013, page 67) highlight an affective dimension by describing *insight* as "a sudden feeling of knowing, or *insight*". In the context of problem solving and creative thinking, the same authors define it in the cognitive dimension as "the sudden realization of the solution to a problem after a period of impasse, the sudden movement from befuddlement to understanding" (Chein & Weisberg, 2013, page 67).

Other authors identify insight experiences on one more dimension. For example, Jung-Beeman et al. (2004, page 4) identify four features to characterise problem solving with insight: "1. Solvers first come to an impasse, no longer progressing towards a solution [...] 2. Solvers usually cannot report the processing that enables them to reinterpret the problem and overcome the impasse [...] 3. Solvers experience their solution as arising suddenly [...] and immediately recognize the correctness of the solution [...] 4. Performance on insight problems is associated with creative thinking and other cognitive abilities different from those associated with performance on noninsight problems". Topolinski and Reber (2010a) also suggest four distinct features: suddenness, ease of processing the solution, positive affect, and the feeling of correctness. In a review of the previous literature, Topolinski and Reber (2010a) identify a change of processing fluency as a results of having an *insight*. After having found the solution, they conclude that the problem appears to be easier than it was during the attempt to solve it. As a result, the difficulty of problematic tasks change in hindsight, independent of how difficult the task appears to be while working on it. For Salvi, Bricolo, Franconeri, Kounios, and Beeman (2015, page 1814) problems are solved by *insight* when "the solutions to a problem suddenly emerges into consciousness in a *Eureka!* or *Aha!* moment". In this, the mental representation of a problem has been restructured. This reorganisation happens suddenly and is often surprising for the problem solvers. Furthermore, they cannot access how they arrived at the solution but are confident in their solution.

In their list of four distinct features, restructuring is the central aspect of an *insight* according to Kounios and Beeman (2014, page 73). This reorganisation is often accompanied by an emotional burst: problem solvers are thought to be surprised by the solution or the process, and they also overcome an impasse. With a reference to the variety of definitions in the literature, Kounios and Beeman (2014, page 73) suggest a narrow and a broad definition of insight. "Very narrowly defined, insight could be thought of as a sudden solution to a problem preceded by an impasse and problem restructuring and followed by a positive emotional response". This gives a clear description of the process: first, an impasse is broken by restructuring, then an *insight* happens, and this is followed by a positive affect. In contrast, the 'broadest' and 'non-scientific' definition of *insight* is "any deep realization, whether sudden or not".

The selection of publications discussed here highlights the fact that currently no systematic way of studying the phenomenon of *insight* exists. Thus, this selection itself could not follow a systematic procedure either, hence the different weights applied to different sections of the literature. It also highlights how diverse the current definitions are and how little agreement exists between authors and studies. Some name two, other four features, and the majority settles with the narratively convenient rule of three. In the selected works, suddenness has been named most fequently, followed by impasse, surprise, and restructuring. However, this list does not suggest that these are the most likely candidates to identify *insight*. In fact, Danek, Wiley, and Öllinger (2016) have shown that not every insightful problem solved relies on restructuring and, in a follow up study, that not every subjective experience of insight and postive affect results in a solved problem. Instead of relying on a theoretical definition to operationalise *insight*, the following section highlights another approach currently used.

2.4.4 Problems as indicator

Instead of using experimental observations as indivators for insight, some authors suggest that certain types of problems can only be solved through insight. Consequently, finding a solution to a problem means that participants had an *insight*. For example, Metcalfe (1986, page 292) defines *insight problems* as "those kinds of problems that provoke a subjective *aha* response upon solution". In the following year, Metcalfe and Wiebe (1987) suggest to define *insight* through the experienced phenomenology and monitored via metacognitive assessments. Here they also imply that restructuring, intuition, illumination, and insight are different names for direct apperception. Later they question if novelty and restructuring are necessary for insight.

Some insight tasks created for one study are later used by other authors. For example DeYoung, Flanders, and Peterson's (2008) tasks are used by others. These authors define *insight* as the moment of overcoming an impasse and finding a new and more effective solution. DeYoung et al. (2008) assume that the problems are ill-defined and restructuring of the dominant interpretation is required to solve these type of problems. This resonates in K. J. Gilhooly and E. Fioratou's (2009, page 356) definition, where it is an *insight problem* if "within the typically derived initial problem representation, the goal cannot be reached and a restructured goal representation [...] is required for solution". To explain the origin of insight tasks, DeYoung et al. (2008) summarise previous literature by linking the ability to solve insightful problems with intelligence, forming remote associations, and pattern recognition. Presumably the task development and task selection is based on these explicit and implicit definitions. Authors using their tasks indirectly subscribe to DeYoung, Flanders, and Peterson's (2008) definition of *insight*.

This relates to Beaty, Nusbaum, and Silvia's (2014) study on personality traits where they also build on the assumption that *insightful problems* elicit *insights*. In their study they administer some of the tasks developed by DeYoung et al. (2008). Even without an explicit definition of *insight*, they therefore expect their participants to break an impasse, find a more effective solution, and restructure the internal representation. Building on this assumption, they find no link between insightful problem solving and personality traits or creative achievement. Also building on the assumption that the task type can be used to distinguish between insight and analytical problem solving, Salvi, Bricolo, Kounios, Bowden, and Beeman (2016) are able to demonstrate that insightful solutions are more often correct than non-insightful ones. Based on previous results from neuroimaging studies, Salvi et al. (2016, page 3) assume that "insight and analytical solutions are produced by different cognitive strategies" within the context of their study.

2.5 Measures

There is no single accepted metric of *insight*. On the one hand, this is a direct consequence from the numerous features of insight discussed in section 2.4.3. Even if 'surprise', 'restructuring', 'positive affect', 'overcoming impasses', and any of the other previously mentioned features could be measured with a single instrument, *insight* would require an instrument tailored to each of the combinations. While each of these hypothetical measures taps into different aspects of the phenomenon, *insight*, as defined in section 2.2.8, can not be measured in this bottom-up approach. Consequently, studies following this approach are referred to in section 2.4.3, but the detailed discussion of each of these combinations is outside the scope of this work.

On the other hand, *insight* is considered to be part of the creative process. According to this alternative top-down operationalisation, measures of the creative process and creativity necessarily include *insight*. In this section I give a short overview of the different tasks used to assess creativity, and how they relate to the assessment of *insight*. Specifically I discuss divergent thinking and convergent thinking tasks, as well as *classical insight problems*. I also touch on the different ways of presenting the task and in particular the stimulus for experiments used to study *Eureka moments*. Since this study is concerned with the moment when solutions emerge, it is essential for me to be able to track temporal aspects of the creative process, so I also speculate on the implications of time and time constraints on the process. I also outline the main methodologies used to trace the *creative process*. In particular, I discuss the methods of verbal protocols, eye-tracking and mouse-tracing and identify their strengths and weaknesses for the research on *insight*.

2.5.1 Divergent thinking tasks

Divergent thinking tasks are designed to assess the ability of an individual to generate many different ideas for a single stimulus (Runco, Abdulla, Paek, Al-Jasim, & Alsuwaidi, 2016; Torrance, 1966). Divergent production is one of the components in Joy Paul Guilford's (1967) 'Structure-of-Intellect' model and is conceptualised as a contributing factor to creative production. A huge number of divergent thinking tasks have been developed, with as much as 53 different tasks analysed in a single publication (Wilson, Guilford, Christensen, & Lewis, 1954). They are commonly administered are unusual uses tasks, and tests drawing on the ability to complete figures, think counterfactually, and interpret ambiguous stimuli. One example for an unusual use task is to name alternative uses for a 'brick' (Wilson et al., 1954). In the 'Torrance Test of Creative Thinking', people are asked to complete a number of drawings, or describe what would happen if everyone could suddenly walk in thin air (Torrance, 1966). Or, the pattern meaning task by Wallach and Kogan (1965) is an example for ambiguity interpretation. The results of this task are scored on several dimensions, most commonly: 1. originality; the uniqueness of a solution within a sample, 2. fluency; the number of solutions produced by one participant, 3. flexibility; the ability to switch between different domains, and 4. elaboration; the detail in which ideas are described. These tasks are difficult to score, in fact Silvia (2008) have evaluated different scoring methods and their reliability. Runco et al. (2016) have evaluated different tasks to see which ones are good predictors of creative production, and conclude that studies relying on only one measure do not provide generalisable results. For different tasks, responses have been linked to intelligence (Nusbaum & Silvia, 2011), professional and domain specific training (Dow & Mayer, 2004; Scott, Leritz, & Mumford, 2004), mood (Baas, Dreu, & Nijstad, 2008), language fluency (Silvia, Beaty, & Nusbaum, 2013), as well as the modalities of collecting ideas such as audio recording and typing speed (Forthmann, Holling, Çelik, Storme, & Lubart, 2017). Furthermore, the instructions play an important role in the number and originality of answers (Forthmann et al., 2016; Taranu & Loesche, 2017).

Traditionally, divergent thinking tasks are thought to mimic early parts of the creative process, to happen in the *preparataion phase* of Wallas's (1926) model. But assuming, that people mentally produce more solutions than they actually communicate, this would assume that a convergent selection of the most promising answer happens. Essentially, this is happening in the top-two scoring method suggested by (Silvia et al., 2008), where participants are asked to select their top two answers for future scoring. During this phase, either internally before communicating an answer or post-hoc, an *insight* can occur. Of course, the nature of *insight* relies on the theoretical grounding discussed in section 2.4.3. If, for example, *insight* is understood as an affect, breaking an imprasse, or changed processing fluency, then it can occur independently of finding a 'correct' solution. Consequently, *Eureka experiences* might occur during divergent thinking tasks, but not as intense as for convergent thinking tasks (Webb, Little, Cropper, & Roze, 2017).

2.5.2 Convergent thinking tasks

Convergent thinking tasks are problems that have one correct solution, but the solution path is not obvious and often requires another approach than following steps of an algorithm. Examples for these tasks are the 'Remote Associates Task' and 'Compound Remote Associates', where people are asked to find the fourth word matching three known ones (Bowden & Jung-Beeman, 2003; Mednick, 1962). While the tasks are designed to have only one solution, this might not necessarily be the case. Taking the normed data from Bowden and Jung-Beeman (2003) as an example, the top question requires a fourth word that matches 'cottage/swiss/cake'. The task only allows the answer 'cheese' as in 'cottage cheese', 'swiss cheese' and 'cheese cake'. Yet another possible answer might be 'mountain' as in 'mountain cottage', 'swiss mountain' and 'mountain cake'; 'mountain cakes' seem to be certain type of cakes – a web search and recipe search delivers many examples and a proficient baker might find this answer more quickly than cheese. The other, more commonly compounds are the Alps as 'Swiss mountains', which also have quite a few 'mountain cottages'. Nevertheless, the answer 'mountain' would not be considered a correct answer for this task. As this example demonstrates, it is not only language fluency to influence the results (Silvia et al., 2013), but also participants' proficiency in the topics the stimuli are taken from.

Convergent thinking tasks are commonly used as insightful tasks (Dietrich & Kanso, 2010; Kounios & Beeman, 2009; Zmigrod, Colzato, & Hommel, 2015). To find the correct solution, participants are required to generate many ideas, similarly to divergent thinking tasks. In fact, Bowers et al. (1990) classifies between different types of stimuli 'triads', some of which are semantically divergent and require an explicitly divergent production to understand the stimulus. Nevertheless, the ability to generate these ideas is not assessed in convergent thinking tasks and might happen at any time. The metrics for these tasks are typically time-related: can a participant find the solution within a given period? And how long does it take them to find it? In some cases these tasks are administered with a maximum time per task, in others participants have a certain amount of time to work on several tasks simultaneously, and yet in others participants are in control of the time. The scoring system requires less subjective judgement of the results by the conductors than for divergent thinking tasks.

In summary and besides these administrative problems, it remains unclear what the convergent tasks measure, i.e. what the contributing factors are, and how the quantification of the results and the single time measure until participants arrive at the solution relates to the underlying creative process. Even with a post-hoc assessment of the subjective experience of an *insight*, these tasks do not allow a detailed analysis of the dynamics leading up to an emerging solution and the processes afterwards.

2.5.3 Insightful tasks

Finally, *classical insight tasks* typically ask participants to come up with a single solution to a riddle or visual puzzle (Duncker, 1935/1963; Gardner, 1978; MacGregor et al., 2001). To reach this goal, the potential problem solvers have to restructure the initial question (Fleck & Weisberg, 2004; Knoblich et al., 1999) or perceive what the original author called the *Gestalt* in an *insight* (Duncker, 1935/1963; Köhler, 1947; Wertheimer, 1945). Following this argument, the focus regarding the problem solving process for this type of tasks shifts towards process knowledge and away from the qualities of the stimulus. Understanding how to solve the problem is more important than the exact features of the involved stimuli. As a result, most of the insightful tasks cannot be repeated with the same person even if the stimuli were exchanged. These training effects between tasks of the same class can be observed for verbal insight tasks (Ansburg & Dominowski, 2000) and visual problems (Weisberg & Alba, 1981). Furthermore and as Bowden et al. (2005, page 323) demonstrate, some of the problems "can be solved without insight if the solver habitually uses a 'What if…' rather than a mathematical strategy'. Similarly, Danek et al. (2016) showed that *insight problems*, despite their name, can be solved without having an *Aha experience*.

For their wit, a number of insightful tasks have by now entered popular culture, so that it is difficult to control for previous exposure of the participants to this or a similar question. While Lung and Dominowski (1985) have demonstrated that solving one task influences the process of solving similar ones, it remains elusive how to identify similarity between different insightful tasks. This includes the modality of the problem. Some tasks are presented in the form of a physical puzzle. This includes problem solving observed in animals Foerder, Galloway, Barthel, III, and Reiss (2011), Köhler (1921/1963), but also human participants are often given tasks in which they have to manipulate physical objects to understand the problem and demonstrate their solution (Adamson, 1952; Ionescu et al., 2017). This type of presentation allows participants to change their own perspective in relationship to the stimulus. The change of spatial orientation of the stimulus from the problem solver's perspective is thought to provoke an adaptation of the mental representation of the problem as well (Ormerod, MacGregor, & Chronicle, 2002). According to embodied cognition theory, the physical engagement with the task supports problem solving and the activation of previous and potentially semantically distant knowledge and memories.

For many tasks the variable of interest is whether participants were able to solve the problem, the time it took to solve it, and to some extent the quality of the solution. In some cases participants are observed or asked to provide a verbal protocol of their thought processes. The tasks can range across a large problem space, from visual or verbal stimuli, to problems that require mathematical knowledge or manipulation of the physical world. Depending on the context of the task, participants' culture, education, and personality traits can influence the measured results. This adds to the conceptual and theoretical problems surrounding the definition of *insight* discussed earlier.

2.5.4 Other tasks and measurements

The Obscure Figures Test as described by Acker and McReynolds (1965) consists of 40 hand drawn figures for which participants are asked to think of something that each figure might represent. According to its authors, some of the figures are draws in a rather obvious way while others are ambiguous and unstructured. Participants are encouraged to respond in "clever, unusual, and imaginative ways, being told that they get extra credits for being creative" (Acker & McReynolds, 1965, page 816). In the 10 minute administration for all 40 stimuli, one response per stimulus is allowed. Responses are scored by the task administrators on a scale between 0 for inappropriate or missing responses to 3 for highly imaginative responses. The study shows a high reliability and correlates well with measures of intelligence. The study relates the Obscure Figures Test to a principle they call *cognitive innovation*[16], the restructuring of internal representations and novelty seeking. According to the authors the novel conception of stimuli is sometimes seen as *clever* or *surprising* and, as a results might have "a particularly "good fit", to lead to an "ah-ha!" experience" (Acker & McReynolds, 1965, page 816). Interestingly this early study shows a correlation with intelligence measures, and also suggest the test as an instrument for studies concerning creativity, curiosity, and reactions. While this task resembles many elements of the Pattern Meaning task published in the same year by Wallach and Kogan (1965), the authors emphasise two years later, that this only represents one of many aspects of the *need for novelty* (Acker & McReynolds, 1967). Consequently and after comparing six different tasks from divergent thinking to stimulus seeking, they call for more caution in generalising results from a single test. In a later study, the Obscures Figure Test has been compared to Unusual Uses Task, the Torrance Test of Creative Thinking, and the Pattern Meaning Task confirming a correlation between these instruments and thus suggesting similar underlying processes (Voss & Keller, 1977). Nevertheless and while the connection between the Obscures Figure Test and the subjective *Eureka experience* has been hypothesised, the rudimentary scoring system does not provide any measures that could help understand the dynamics of the process or observe the moment of interest any better.

Another approach to *Eureka experiences* provide jokes and humour. Gick and Lockhart (1995) open their chapter on *Eureka* moments with a joke. They claim, that the sudden understanding of the punch line is an *insight*, often with an affective component. Jokes are often told in certain social sit-

[16]not to be confused with *Cognitive Innovation* as defined 50 years later within the context of CogNovo, also see Kristensen et al. (2017)

uations and with the listeners expectation to hear something funny. This environment can be used in the narrative to strengthen the effect. One well-known example is the 'yellow sheep joke', a longer form of a humorous story playing with several elements of classical jokes. Interestingly it also resembles elements from 'serendipity' as discussed in section 2.2.7 by telling the story of three brothers sent out to the world by their father to find and rescue a lost valuable item, in this case a 'yellow sheep'. With the classical structure, the listeners expect a solution or joke for the third brother, but the joke ends with nothing extraordinary and the 'yellow sheep' has not been found. At this point, the expectation of the listener is violated and they are often disappointed. Some time later the story teller offers a compensation for the failed joke by offering another story. This part of the joke is on a very different topic, but at some point the leading character in this second story finds the 'yellow sheep' in an unexpected situation. Considering the initial story as an unsolved problem, the unexpected and surprising solution offered in the second part can be considered a triggered *Eureka* experience. In their encyclopedic entry on humour and creativity, O'Quin and Derks (1999/2011) suggest that the strength of *insight* in jokes relates to the humour appreciation. They also emphasise that the vast amount of research on humour production and humour appreciation is often not recognised, the "interface between the fields of humo[u]r and creativity is thus clouded by these perplexities" (O'Quin & Derks, 1999/2011, page 634). Humour and jokes seem to be related to *Eureka experiences* through creativity, but following the discussion on the already ambiguous relationship between creativity and *insight* in section 2.5 they were not considered for the further work in this thesis.

2.5.5 Temporal aspects of task administration

The *Eureka moment* is a point in time. Consequently, tasks related to *insights* should be linked to temporal aspects, and many tasks described in this section are indeed administered with different degrees of time constraints. One group of tasks is administered with a defined time per task that cannot be altered during the experiment. For example, participants have exactly one minute to generate as many answers as possible for one stimulus. Other tasks are administered with a maximum time per task, for example giving participants up to two minutes to answer the question, but they can advance to the next item at any time before that. In other set-ups, participants are given either a total time or a maximum time for a group of stimuli. Alternatively, another group of experiments allows participants to advance at their own pace, not putting any time constraints on them, but potentially measuring the switching times. This approach can be distinguished into two subgroups: either participants can only advance to the next stimuli, or they can switch back and forth between the given stimuli. In these paragraphs I want to discuss implications of these different types of task administration. Eventually, this informs my decision for methods used in this thesis.

Experiments administered with predefined times allow to observe a time slice of the creative process of participants — independent of task difficulty and individual differences. In some of these tasks the researchers assume that the probability of generating one or more solutions after the maximum time is low. Other studies use the cut-off time to distinguish the individual difference in processing speed through the assessment of task progress within the given time. Yet another set of studies appears to be using a predefined time for convenience, as it allows easier task administration and simpler data analysis. In any case, and assuming that *Eureka moments* happen as a function of time, participants experience the *Eureka moment* either within the defined time period or after the assessment time ends. If participants have the *Eureka experience* within the task time and are forced to stay with the task until the time runs out, they may spend the remaining time verifying the solution. The longer verification phase influences the confidence in the solution and potentially even the solution itself. The predefined task time either lets participants experience the *Eureka moment*, or it does not. This depends on task difficulty, individual differences, motivation, environment, and a number of additional factors. For people who experienced an *Eureka moment*, the time between this experience and the end of the predefined task time has a modifying effect on the result, either weakening or strengthening it. A way of reducing one of the modifiers is to introduce a maximum task time instead of a fixed time. The given answers within the task time presumably still depend on the same factors as for the fixed time condition, but the verification phase is reduced, at least in most of the cases. In particular if participants are encouraged to answer as quickly as possible, their verification is most likely reduced. There will still be a number of participants who will spend time on verifying the solution or solutions, but people don't have idle time. This is particularly true for convergent thinking tasks or in general tasks which require one single answer.

In another group of experiments, participants are not given a set task time, but rather a total time for all experiments or at least a group of tasks. There are two possible subgroups for this. In the first group, participants can freely switch between the individual tasks. In the second group they strictly progress from one task to the next, but without constraints on individual tasks. In both cases they can either be encouraged to solve as many tasks as possible or rather to focus on the quality of individual solutions. This difference in instructions will likely lead to differing results. Here I discuss the influence of the task group time on given answers.

If participants encounter one stimulus at a time, but without time constraints on this single task, they might generate as many answers as possible for as long as they feel confident about the quality of their answers. If the task is a divergent thinking task they will communicate these answers while generating them and move on to the next task once this initial set is generated. In a convergent task these answers might be generated internally before converging to a single answer and continuing to the next task. In insightful tasks they might test all generated ideas and give an answer if they found a working solution, before continuing to the next task. If they have not found a solution, they might return to the idea generation part for a second or third time, and advance without giving a solution after a number of unsuccessful iterations. The size of the generated set of ideas in the divergent part of the task, the depth of verification in the convergent part, and the number of iterations for the insightful task, all depend on a number of factors. These components include motivation, individual differences in capacity of working memory, individual domain knowledge, and other factors difficult to control for. If participants are free to go back and forth between individual tasks, then they might advance earlier to the next task knowing they can return the current task at any time. While already working on the next task and depending on the required cognitive load for this one, they might continue incubating on one of the previous tasks and generate a solution for the initial problem. According to the immediate incubation described in Kenneth J. Gilhooly, Georgiou, Garrison, Reston, and Sirota (2012), participants might even work on all tasks at the same time if they are given the chance to look at them early on. Since I am interested in the time when participants have a *Eureka experience*, this might be a result of incubation rather than focussing on a single problem. On the other hand, the number of solved problems and the reported *insights* within a given task group time is less dependent on a single task. One prominent example for a task group time are the Torrance Test of Creative Thinking (TTCT), which gives participants 10 minutes to respond to a group of stimuli. In a sense and on a more abstract level, tasks that are run in a lab generally fall under this category as well: participants are given either a certain time for the whole experiment, either explicitly by rewarding them with course points or money per given time spent on an experiment. For example, participants know in advance that they are rewarded for 30 minutes of their time, even though the experiment itself might consist of smaller timed subparts. Even without this extrinsic limitation, any participant might be driven by their own intrinsic desire to finishe the experiment as soon as possible. The consequence for any experiment is to create the task as an enjoyable experience that motivates participants and counters or neutralises the previously described effects.

Participants spending as much time as they want on tasks are constrained by different implicit and explicit factors. As mentioned before, one of these moderating factors is the motivation to solve the task, which can be either intrinsic or extrinsic. According to Prabhu, Sutton, and Sauser (2008), it appears that intrinsic motivation fosters creativity, while extrinsic motivation hinders it. However, other studies arrive at contrasting conclusions (Amabile & Pratt, 2016). On a more fundamental level, an increase in either type of motivation will result in an increased time that participants spend on the task. From the outside it is not possible to distinguish whether participants spend all or just parts of the allocated task time actively solving the problem. In fact Seli, Risko, Smilek, and Schacter (2016) show that unintentional mind-wandering happens in most tasks — in addition to the participant-initiated intentional drift away from the task. Nevertheless, from a merely statistical point of view, it seems plausible that an increase in task time also increases the time participants actually spend focusing on the task. With regards to the experimental design, the task time can be increased through motivation. It is possible that there is a correlation between task time and the probability of solving a problem and generating more answers, possibly mediated through motivation. If this is the case, then the results of tasks administered without a time limit will reflect the time and motivation of participants to a certain extent, possibly to a greater extent than their individual creative ability. Given that early phases of problem solving have a time component as well, the ability to process all necessary information and potentially overcome an impasse to reach a *Eureka moment* will depend on the task time and on the motivation of the participants.

If participants have little motivation to complete the task giving them a maximum time for a task or group of tasks, or no time constraints at all, it is likely that they will answer as quickly as possible, without giving the task itself much thought. Participants who have a higher motivation will spend more time and, as a result, advance to different phases of their problem solving process. To overcome this initial difference, a minimum time per task or per group of tasks can be introduced. In this case participants know they have to spend at least a certain amount of time on the experiment. Since they cannot use their time for anything else, they might just as well spend the time in the attempt to solve the given problem. As for the intrinsic motivation, there are strategies than can be introduced to increase it as well, for example through gamification (Sailer, Hense, Mayr, & Mandl, 2017).

In summary, time constraints are of vital importance for any task related to *insight*. Each task with a single answer that potentially elicits a *Eureka experience* should have their own time constraint, preferrably a maximum time instead of a fixed time per task. A minimum time has the potential of extrinsically motivating additional participants that feel otherwise forced, but this time needs to be carefully chosen. In addition to these extrinsict factors, the intrinsic motivation plays an important role in the task time.

Theoretically, an enjoyable task will motivate participants to think about the problem as long as they need to find a solution. Generally, longer on-task time increases the probability of finding a solution through *insight*, but needs to be distinguished from time spent with the task while actually attending to other problems or mind-wandering. Once again, the task type and intrinsic motivation have a positive effect on the temporal aspects of the task administration.

2.5.6 Verbal protocols

Verbal and think-aloud protocols have been often used in insightful tasks (Fleck & Weisberg, 2004), divergent thinking tasks (Kenneth J. Gilhooly, Fioratou, Anthony, & Wynn, 2007), convergent thinking tasks (Cranford & Moss, 2012), and also in real-world problem solving (Kozbelt, Dexter, Dolese, Meredith, & Ostrofsky, 2015; Newell & Simon, 1972). While Schooler et al. (1993) suggested that these protocols might produce an overshadowing effect for insight problem solving, Kenneth J. Gilhooly et al. (2007) did not find any effect on fluency and novelty production in a divergent thinking task. In a meta-study, Fox, Ericsson, and Best (2011) did not see an effect of verbalisation on the results of tasks, but they did notice an increase in the time required. These results suggest that think-aloud protocols might or might not change the solutions provided for a task, but they most certainly change the process. Furthermore Beeftink, van Eerde, and Rutte (2008) have shown, that self-initiated breaks were benefitial for *Eureka experiences* while imposed interruptions led to fewer *insights*. Verbal protocols can be argued to be self-initiated but also forced. With my interest in narrowing down the time of emerging solutions within a process, it seems that these protocols might not be appropriate for the task at hand.

2.5.7 Eye tracking and mouse tracing

Besides the verbal protocols discussed in section 2.5.6, eye-tracking (Thomas & Lleras, 2007) and mouse-tracing (Freeman & Ambady, 2010) are commonly used techniques to study the behaviour that leads to problem solving. However, these techniques require computer-based tasks, and they are based on the fundamental assumption that psychological processes can be traced through observable behaviour (Skinner, 1984). Of particular interest for the emerging solutions is the participants' behaviour during a task when they engage in a creative problem solving process. In order to solve a task, people have to engage with elements that can provide them with the knowledge needed for the solution. The order and duration of engagement with these elements shows the information aquisition process.

In a direct comparison between eye-tracking and mouse-tracking, Lohse and Johnson (1996, page 37) conclude that mouse interactions "predispose people to use a more systematic search and process more information than they normally would". To maximise the effect of the mouse tracking technique, Ullrich, Wallach, and Melis (2003) suggested to blur elements not directly under the mouse pointer. This prevents people from accessing information away from the mouse pointer and gives better control over the supposed focus of attention. Uncovering elements on screen implies that information acquisition and information processing is possible throughout the whole hover time. Indeed, participants will not necessarily direct their full attention to the currently unblurred text or image. While this appears as a disadvantage of mouse-tracking, Ferreira, Apel, and Henderson (2008) have observed the same issue for eye-tracking. People are also known to not always perceive visual input when generating ideas (Walcher, Körner, & Benedek, 2017). Furthermore, other processes such as memory access are related to eye movements as well (Johansson & Johansson, 2013; Scholz, von Helversen, & Rieskamp, 2015). Finally, Freeman and Ambady (2010) have shown that mouse-tracking provides reliable insight into mental processes. Consequently, for computer-based tasks and with areas outside the mouse pointer's position being inaccessible, mouse-tracking provides a similarly robust measure as eye-tracking, and it has the advantage of being easier to administer.

2.6 Problem Solving

As part of their effort to study human behaviour and artificial intelligence, Newell et al. (1958) described the elements that a theory of problem solving should address: specifically, it should predict the performance, explain the processes and mechanisms involved, and specify the phenomena accompanying problem solving as well as their relation to the process. According to this list, a theory of problem solving should not just show how a change of the problem alters the behaviour but also what has been learned after finding the solution. The language Newell et al. (1958) use is informed by their previous work and education in computer science, and particular information processing theory.

The information processing theory is based on the mathematical works by Shannon and Weaver (1963) concerning technical communication between devices and, in a wider sense, how information can be processes in machines. The information processing theory in cognitive psychology builds on the idea that humans in their attempt to solve problems, follow a similar approach as computers. In this view the human brain has units that function as short time, long time, and working memory; as connections to the different sensory inputs and motor effectors, and as a central processing unit that computes information by manipulating content of the working memory. In their book Newell and Simon (1972) aim at understanding how these cognitive systems can interact and how this interaction solves problems.

2.6.1 Concept Analysis of the term *problem solving*

In information processing terms a problem is defined by a problem space, a search space, and a representation of the problem itself. The problem space is the internal representation, which differs from the stimulus and environment, but represents aspects of it. Problem solving is then the path on how to come from the problem to the solution.

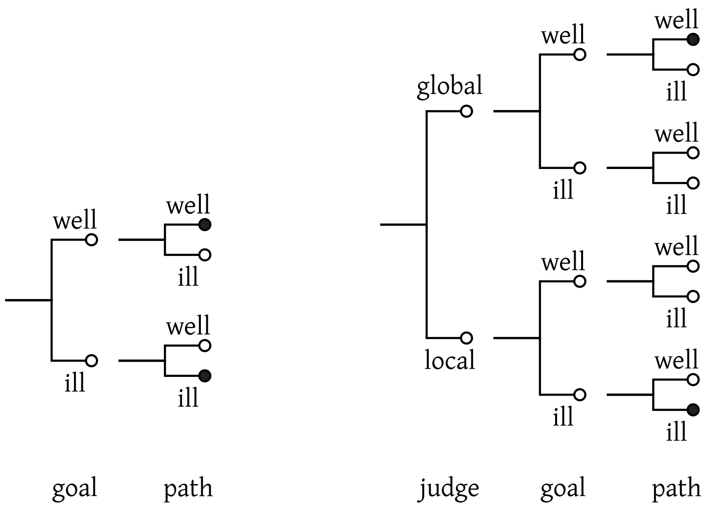
The term *problem solving* consists of two words. *Problem*, the first one, describes a situation or a state that should be changed or overcome. States, in a very abstract sense, represent positions in a space. The dimensions of this space can represent knowledge, spatial, temporal domains, or a combination of any of these. A problem is then the acknowledgement of the discrepancy between two states, one representing the start and the other one the more desirable goal state. *Solving*, the second part of the term, is a verb describing the process of finding a solution. Therefore *Problem solving* describes the process of moving through the defined space towards the goal state, reaching the goal solves the problem. From this description, a number of observations and implications can be inferred. 1. The existence of the goal state, which has to be different from the current one, needs to be identified, and 2. the there is some way of judging if the goal state has been reached. 3. There needs to be some kind of drive or desire to leave the current position and strive towards the goal which requires 4. the current state and the goal to be part of the same knowledge or problem space. Besides the drive there also needs to be 5. actions that implies planned movement. In short, problem solving describes the transition from one state to having reached a goal. The following section discusses the difference in language.

2.6.2 Goals and Problem Definition

Looking at the goal more specifically, problems can be classified into two categories: they are either well-defined or ill-defined. Whenever the expected outcome is clear and known from the beginning, then the goal is said to be well-defined. Herbert A. Simon (1973) argues that ill-structured problems can only be understood as a residual concept, as a definition of what it is not. In this case ill-defined problems are not a well-defined problems. Examples for well-defined problems could either be a single expected solution, or criteria defining the goal more vaguely. One example for a concrete goal would be to find the shortest way on a map from one point to another or the remote associates task (Mednick, 1962) previously mentioned in section 2.5.2. There is only one solution for each task. A more vague goal definition would be to find any word that starts with the same letter as two other words. The transition or action to reach the goal can be just as well-define or ill-defined. For example in a number of simple mathematical problems the solution path is well known and finding the answer to the problem is merely following this set of rules. For the ill-defined solution path there is no known way between the current position and the goal.

To identify if a problem is solved, the process requires some way to evaluate the current state. This judge could either be an external entity informing the problem solver about the success, or some internal judge, potentially aided by the intrinsic properties of the task. After each state change, this judge would need to very the current position in the space in relation to the desired goal state. If the problem space and position of the goal is known to the judge, then it is possible to identify the current distance to the solution. This resembles the idea of a gradual and analytical process and is represented by the 'global judge' in fig. 2.2. On the other hand, if the space is unknown or the goal is only defined through constraints but has no position associated, then the judge will only be able to report if the solution was found or not ('local judge' in fig. 2.2). This shows some parallels to features of *insight* mentioned in section 2.4.3, such as suddenness, surprise, or inability to report the solution process.

Looking at the problem solving process as a whole, Herbert A. Simon (1973) concluded that the boundaries between well-defined and ill-defined problems are rather vague. He defines an ill-defined problem by stating that both, the goal and path have to be ill-defined. This definition accounts for four different categories of problems: the goal to be reached is either ill-defined or well-defined and the path or reaching it is ill-defined or well-defined. I suggest to call the types of problems that have a well-defined goal and a well-defined path the 'truly well-defined problems' as they comply without question with Herbert A. Simon's (1973) suggestion of a well-defined problem. If the knowledge of the judge is considered as well, then problems using judges with global knowledge could be considered well-defined. Hence problems with 'global knowledge', 'well-defined goals', and 'well-defined paths' could be considered well-defined. I have marked these problems in fig. 2.2 with a filled circle. Similarly I have marked the 'truly ill-defined problems'. While there might be more aspects to consider, this current example illustrates that Herbert A. Simon's (1973) classification is ambiguous regarding certain problems, namely those with a mix of well-defined and ill-defined aspects. These problems, in fig. 2.2 left with an empty circle, are a considerable amount of all possible problems.



(a) Categorisation of problems considering goals and paths, resulting in four different types of problems.

(b) Categorisation of problems considering the knowledge of judges, goals, and paths, resulting in eight different types of problems.

Figure 2.2: Comparison of problem categorisations for well-defined and ill-defined goals and paths (left). If the knowledge of the judge is considered as well, then this would result in a larger number of possible problem types.

2.6.3 Types of problem solving

According to Novick and Sherman (2003), solutions found through a variety of problem solving methods fall into one of three classes: *pop-out*, *search*, or *memory retrieval*.

Pop-out solutions as mentioned by Novick and Sherman (2003), refer to the class of solutions retrieved through *insight* "while still avoiding the extra connotations inherent in the Gestalt view of insight" (Novick & Sherman, 2003, page 352). This is contrasted to the *search* going back to the use by Newell and Simon (1972) who have described problem solving in set-theoretical terms. For them, finding a solution is identifying a subset in the problem space that has specific properties of the goal-set. This means, that the solution is part of the internal representation of the problem space since the beginning of the task. Problem solving is then a set or sequence of manipulations within the search space that helps identifying these subsets. In this setting, task difficulty is a results of size of the problem space, the sparsity and distribution of solutions across the space, and the cost of manipulations. This search can also be represented through manipulations on spanning trees. Newell and Simon (1972) discuss this theory in the context and analysis of verbal protocols with humans trying to solve a number of problem such as cryptoarithmetic puzzles and chess problems. The term 'search' is used by Novick and Sherman (2003) in a broader sense, as a strategy to deliberately and incrementally transition from the start to the goal state. Intermediate results stored in working memory allows to revisit the path towards the solution, which requires distinguishable ideas and concepts (Feist, 1991). While Metcalfe and Wiebe (1987, page 240) referred to them very descriptively as *grind-out-the-solution*, Salvi et al. (2016) referred to this strategy simply as *analysis*.

Interestingly the theory by Newell and Simon (1972) includes moments of "functional fixity, the Einstellung effect, insight, incubation" (Newell & Simon, 1972, page 872). They explain this phenomenon as *working-backwards*: In some cases problem solvers who have hit an impasse, apply transformative steps away from the goal state to reach branch in the spanning tree representation from which the goal is easier to reach. They account this as a potential double function of an expression and a related functional fixity, but provide no speculation on why some of the participants are able to resolve the situation while other can not. Interestingly the verbal protocols of some of the participants in the experiment suggest affective *Aha moments* for the *working-backwards* episodes: "No, how can I get that? *Ah*, probably by using two lines." Newell and Simon (1972, page 578).

2.6.4 Behaviouristic problem solving

In Psychology, the behaviourist approach to problem solving builds on the idea of trial-and-error and behavioural conditioning. Here a temporary solution is generated and then checked against the goal constraints. If the solution is not found, the attempt is repeated with variations of the temporary solution. Actions that lead to positive feedback and successful solutions are strengthened and more likely repeated in a similar task. An experimental approach to study this type of problem solving was introduced by Thorndike (1911). He observed the duration it would take cats and dogs to escape puzzle boxes to the food placed outside. He developed a model for the observed times which suggests that the animals initially triggered the opening mechanism by accident. Thorndike explained shorter times observed for repeated experiments by strengthened associations between a learned interaction and the received award, and longer times by weakened associations of experiments in which the test subjects did not solve the problem. Interestingly Thorndike (1911, page 239) mentions the "general function of having free ideas", a phenomenon similar to insight, by referencing an experiment with apes and also relates it to human problem solving. He hypothesises that a certain state of mind or development is needed to experience this phenomenon, a far greater number of associations than in other mammals and something he seems to equate with consciousness. Furthermore he explains the generation of these associations in humans through their "curiosity, and satisfaction at activity, bodily or mental, for its own sake" (Thorndike, 1911, page 281). While the satisfaction seems to refer to intrinsic motivation, the exact connotation of *curiosity* remains unclear. He refers to it as an emotion and names the *useful curiosity* as the reason human "discoveries, such as the use of tools, the art of makeing fire" (Thorndike, 1911, page 151). So while he is opposing the idea of *insight*, there are still some aspects of his theory that he seems to take for granted and does not see a need to explain it in more detail. Potentially either *free will* as an emerging phenomenon or *good curiosity* could have a notion of the topic of this thesis, the emerging solution.

2.7 Creativity

Another concept which is tightly related to insight, and which, just like insights, has been puzzling researchers for decades, is that of creativity. As we have seen, insights are inherently associated with *creative* problem solving, so let me dedicate some pages to this concept as well.

"Creativity requires both originality and effectiveness", conclude Runco and Jaeger (2012) in their 'Standard Definition of Creativity' after a reading of the scientific literature back to the 1930s. These two dimensions, sometimes also labelled novel, unique, or unusual and useful, appropriate, or valuable respectively, are mentioned an repeated throughout the literature when referring to creativity. Languages in the western world only started adding the word *creativity* to the dictionaries in the late 19th or early 20th century (Weiner, 2000). In fact, most ancient cultures did not know the concept of creativity. Instead they had concepts such as that of the *muses*, inspirational goddesses who would visit eminent people from time to time and provide them with knowledge and inspiration. Others, like Plato, heard voices that would hold him back when he was about to make a mistake. From this occasional visit to selected people, the inspiring divine entity developed into a personal guardian, the *genius*. Every person had one, a female Juno or a male Jupiter, that would follow them from cradle to grave. Developed around the same time as Christianity, this idea was closely related to the idea of a soul. These *geniuses* had different abilities, some of them were stronger, some weaker, but there was nothing humans could do about it. From the 14th century on, the word was only used for people who had a *strong genius*, while weaker ones were not referred to any more. Eminent people like kings and queens, and later also outstanding clergy, painter, and merchant, would be referred to as *geniuses*. By the time of the Renaissance, genius was defined as "the faculty of invention; by means of which a man is qualified for making new discoveries in sciences, or for producing original works of art" (Gerard, 1774, page 8), thus apparently unlinking the concept from a purely divine intervention. Shortly afterwards, Kant (1790) situated genius entirely in the individual, but genius was still considered unteachable knowledge. Consequently, genius defined eminent people, mostly man. Galton's (1869) qualitative study of eminent contemporaries assumed that genius was hereditary, with intelligence as a necessary prerequisite. This research shifted the attention from the *artefact* that geniuses created to the *actor* who created it. Historiometric studies have since then found correlates between perceived genius and intelligence (Batey & Furnham, 2006; Cattell, 1903), mental illness (J. C. Kaufman, 2014), personality (Eysenck, 1993), talent (Ackerman, 2014), genes (Reuter, Roth, Holve, & Hennig, 2006) and other traits. In addition, and through the writing of eminent creators such as Helmholtz, Kekulé, Einstein, Freud, and Picasso, cognitive processes and the *actions* generating the *artefacts* have become of interest. Here the psychological study of *insight* as part of *productive thinking* began in the Gestalt School, but other psychologists became interested as well. This is also the time when the term *creativity* was coined as an interdisciplinary term to describe similarities between artistic and scientific creation. A pivotal moment for creativity research was the presidential address of J. P. Guilford (1950) to the American Psychological Association, where he inspired his colleagues to systematically research creativity. In the following two decades, the ratio of literature on creativity increased from less than 2 ‰to up to 7 ‰(J. P. Guilford, 1970).

2.7.1 Classification of creativity

About five years after J. P. Guilford's presidential address to focus on the research of creativity, Rhodes set out to find a definition of creativity. From about 300 articles he collected 40 definitions. After further analysis of their content, he identified four different strands, which he called the "four P's of creativity": person, process, press, and product. He notes that "each strand has unique identity academically, but only in unity do the four strands operate functionally" (Rhodes, 1961, page 307).

The first strand on the *person* observes personality traits, attitudes, physiological, and psychological factors' influence on creativity. It discusses intelligence as an enabler, the identification of gifted people, the ability to be puzzled and think critically and the will to persistently stay with a problem. The second strand on the *process* mentions the descriptions of thought processes mentioned by von Helmholtz and Wallas, but at the same time it implicitly references the historical dimensions. This leads to the research on the relationship between individuals and their environment, which is grouped into the third strand, what Rhodes calls *press*. He mentions that creativity can be seen as a response to social needs, but at the same it builds on previous cultural and technological advances. In addition to the cultural dimension and its *Zeitgeist*, the press potentially also refers to the broader evolutionary aspects as well as the influence of the very local place. In fact, in some later literature, press was replaced with *place*. Finally, research on the *product* refers to materialised ideas and tangible outcomes. Rhodes (1961) hypothesises that objective research on the creative process proceeds in one direction, from the product to person, to process, to press. In this framework, research about the Eureka moment might be considered to be part of the strand about the product, the process, and possibly the press: the product has come into existence at some time, possibly through a Eureka moment. Research on the process of creativity potentially also looks at Eureka moments. Finally, as broadly as Rhodes conceptualises the press, cues and changes of and in the environment relate to Eureka moments. However, their nature is such that each of the three mentioned strands could also be argued to have no connection to the Eureka moment: the product as the materialisaton of an idea does not necessarily need to depend on a Eureka moment, in fact judges might not be able to distinguish between Eureka and non-Eureka products. Similarly concrete implementations of the process might or might not rely on a Studies on the Eureka moment, for example some assessments of the Remote Associate Task (Mednick, 1962), rely on self-reports whether or not Eureka moments were part of the process. Finally, the press can be seen primarily as either a rather static place, or as an interactive environment potentially triggering a Eureka moment. Thus, the distinction offered by Rhodes (1961), even though helpful and influential for research on creativity, is not particularly useful for a discussion of Eureka moments.

Simonton (1988), without directly referencing Rhodes (1961), identifies four ‘P’ in research on creativity as well, namely *process*, *product*, *person*, and *persuasion*. While the first three categories show a great overlap with the strands identified by Rhodes (1961), Simonton as a social psychologist focuses primarily on the influence of creative achievement on other people. Persuation, the influence on other people, suggests that some results trigger ideas in other cases of creativity. While this seems to suggest a stronger focus on Eureka moments, persuasion remains ambiguous and Simonton's distinction is not much more helpful for research on Eureka moments.

Runco (2007) mentions creative potential as yet another distinguishable 'P'. Consequently he argues that the model by Rhodes (1961) is too simplistic to account for the increasingly complex research on creativity. Runco suggests a hierarchy with at least three levels to reflect the state of research. Following this idea, the most basic distinction is between creative potential and creative performance. In this setup 'person', 'process', and 'press' are part of the potential, while 'products', 'persuation' and 'interactions' — for example between person and environment — are suggested to be part of the performance side of creativity. Within the educational context of this article, Runco (2007) suggests that this hierarchy helps to identify what facilitates everyone's creativity. Instead, elements that are part of the creative performance manifests creativity that is already there. The top level distinction between potential and performance as suggested by Runco (2007) separates seemingly static categories from the dynamic aspects. In this classification, the 'interaction' can be understood as the influence between person and process, or process and press at a certain time, hence it separates the research of an applied and dynamic process from the static idea of how a process could influence creativity. As a result, the meaning of 'process' changes as compared to the use of Rhodes (1961), and press gets further divided into the possibility a place and environment offers versus the research on the actual 'interaction'. The distinction suggested by Runco (2007) offers more possibilities to classify research on Eureka moments: from his interpretation, they are primarily related to the performance part.

In an attempt to "incorporate insights from a series of emerging inter- or multidisciplinary areas", Glăveanu (2013, page 70) suggests a framework of *five A*" instead: *actor*, *action*, *artifact*, *audience*, and *affordances*. This model is different from Rhodes's (1961) *P* models. First of all, it shifts the focus on the individual from traits of a single person to attributes within a societal context, and from the attempt to describe the features of a product to its appreciation in a cultural context. Also, instead of cognitive processes, Glăveanu (2013) suggests a focus on psychological and behavioural manifestation of actions, and distinguishes between the audience and the affordances of the press: while the interaction with an audience can be dynamic and unexpected by nature, affordances as a property of the physical world are predictable by nature. The changed emphasis on aspects of creativity also shifts the attention towards Eureka moments: while research on actors, artifacts, and affordances because of their static nature are less likely to yield results regarding Eureka moments, the emphasis of behavioural action and the audience interaction indicates a stronger emphasis on temporal aspects, and hence the potential to be interesting for research on the Eureka moment.

2.7.2 The Democratisation of Creativity

Not every creative process or creative product is the same, some are novel and useful just for a single person, others might change the world. Boden (1994) uses the terms P-creativity and H-creativity to distinguish between the two. She defines the psychological or personal P-creativity as "new *to the person who comes up with it*" (emphasis in original) and writes "if a new idea is H-creative, that means that (so far as we know) no one else had it before" (Boden, 2004, page 2). This is related to the distinction between *originality* as a psychological concept and *novelty* as a historical fact, as discussed by Koestler (1964). Taking into account that the attribution of discoveries changes over time and based on new discoveries by science historians, she concludes that there "can be no systematic explanation of H-creativity, no theory that explains all and only H-creative ideas" (Boden, 1994, page 521). In addition to that and taking into account that other worlds like ours might exist in the universe, there will never be any certainty, if not that another life form on another planet might have had the same ideas millennia ago. Nevertheless, each H-creative idea is P-creative as well. Hence the exploration of P-creativity will also account for the processes responsible for H-creativity. Consequently, the Eureka moments that have been preserved as anecdotal reports might have changed science or the arts, but foremost they are also psychological and personal experiences of an individual. Therefore these moments of discovery are similarly part of the creative process of a child in Kindergarten discovering cohesion of wet sand and consequently using it to build castles, of a restaurant chef trying a new combination of spices for a dish, as well as of Archimedes' discovery of the specific gravity of things or law of Buoyancy (Hidetaka, 2010).

A similar distinction has been made between the study of extraordinary creative accomplishments and everyday creativity, called *Big-C* and *little-c*. Big-C is often seen as the result of an ability to create that has been build up over years of practice and devotion. This line of research on eminent creativity is closely connected to the idea of genius, further discussed in section 2.7. Little-c, or mundane creativity, on the other hand focuses on everyday creativity, on the ability to creatively solve problems, the potential of nurturing creativity in educational settings, and the impact of creativity on today's society. The category of little-c allows to account for artistic artwork that cannot compete with Salvador Dalí or Cormac McCarthy, it allows to define work environments that foster higher quality design output, and contributes to solving increasingly complex real world problems.

With the argument that little-c captures too broad a range of creative processes, Beghetto and Kaufman (2007) suggested mini-c as a third category related to the construction of personal knowledge and learning. J. C. Kaufman and Beghetto (2009) suggested a fourth category of pro-c, the kind of creativity people are trained to use in a certain discipline throughout their work. Building on the componential framework by Amabile (1983), who mentions domain-relevant skills as one of three necessary components, they argue that a long and in-depth training in a certain discipline results in a distinguishable creativity. This fourth C of the "four C model of creativity" is not as eminent as the Big-C, but the laypeople's everyday little-c and developmental mini-c are still significantly different. J. C. Kaufman and Beghetto (2009) argue, that some of the factors that differentiate between pro-c and Big-C are acknowledgement by peers and gatekeepers. Even though evidence has been found for the hypothesis that long training and engagement increases the production of artistic output (S. B. Kaufman & Kaufman, 2007), J. C. Kaufman and Beghetto (2013) failed to show that laypeople recognise the difference between little-c and pro-c.

In the four c model of creativity, each of the three or four types of creativity have the same personal or psychological moment when they solve the problem at hand, have an idea, or understand the solution. For the child having a mini-c in the sandbox at the kindergarten this moment happens when they realise that the difference between the sticking sand and the non-sticking one is the amount of water. In little-c any time a problem is solved creatively, someone didn't know how to solve it at one moment and suddenly understood the solution at another one. For pro-c the professional working on an assignment suddenly finds a solution that works. And even if one solution turns out to be considered Big-C at some point, someone must have had the same idea previously, at a lower level. The argument is very similar to the one that every historic creativity (h-creativity) relies on a personal creativity (p-creativity). Even if there are different types of creativity and people might or might not be able to distinguish between them, they all have this moment of creation, the Eureka moment, at its core.

2.7.3 Innovation

Innovation is the implementation of creative ideas. The term is primarily used to describe the creative processes in organisations (Amabile, 1988) or creative *artefacts* (Weisberg, 2006). Further, the term is starting to gain exposure in STEAM research groups, in the compound term *Cognitive Innovation*. *Cognitive Innovation* describes a transdisciplinary approach to research and is being researched through this process itself (Kristensen et al., 2017). However, in the context of this work I refer to *innovation* as "implemented creativity".

2.7.4 Linear creative processes: Sequential models of creativity

To describe the creative process and its components, psychologists predominantly use a linear sequence of predefined stages. One of the oldest and best known models was published by Wallas (1926). Inspired by the writings of von Helmholtz (1896) and Poincaré (1910), he developed a model of creativity that consists of five consecutive stages. He referred to them as *preparation*, *incubation*, *intimation*, *illumination*, and *verification*. Often only four stages are referred to and *intimation* is dropped, even though the reason is not apparent from the original text (Sadler-Smith, 2015). Once a problem is defined, the process starts with the initial stage, *preparation*. Here the prospective problem solver investigates the problem in all directions and accumulates as much intellectual ressources as possible that will help to solve the problem. At some point, and if the problem is not solved, then the person enters the second stage coined *incubation*. During this time no conscious effort is directed towards the problem. Moreover people might work on other problems or focus on different tasks altogether. During this stage, thoughts connected to the initial problem might involuntary pop up at unforseen times, but progress is not discernible. At some point, a feeling of a rising thought starts and becomes stronger over time, which corresponds to the *intimation* phase. Then, and often described as sudden, a solution to the problem appears during the phase of *illumination*. Here, some elements from the preparation 'click' together and create the *insight* that was previously defined in section 2.2.2 and is in the center of interest for this thesis. At this point the problem solver might have the feeling that the solution is correct, but the phase of *insight* is too short to verify potentially complex problems. This is done in the *verification* phase, which is the last part in Wallas's (1926) model.

Many other sequential models have been developed to highlight different aspects of the process or explain experimental data. In some cases the model starts earlier in the process with the problem finding phase, in other cases an additional phase of communication is added after the *verification* (Csikszentmihalyi, 2009). In yet other cases the process is subdivided into different parts and different numbers of parts. Howard, Culley, and Dekon-

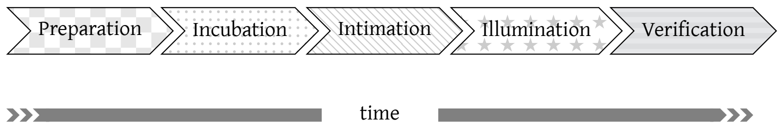


Figure 2.3: Example for a sequential model of creativity, based on Wallas (1926)

inck (2008) provides an overview of 19 different sequential models. The majority of these models have a phase or transition in which the prospective problem solver passes from not knowing to knowing the answer to a problem. For the discussion of the phenomenon of emerging solutions it does therefore not matter which model to use. Becaues Wallas's (1926) is probably the best known one and the description of the phases are intuitive to understand, I use this model as a placeholder for other sequential models throughout this work.

2.7.5 Design thinking

There is another angle to look at the story about Archimedes and his Eureka moment: the oldest known source for this anecdote is a book about Architecture, written about 200 years after Archimedes had lived(Pollio, 15/1914). This implies that Architects have been interested in the problem solving process for a long time. Given the nature of their work, they seem more interested in understanding the creative process for pragmatic reasons: the ability to influence the quality of solutions, as well as the timing of solving a problem, is crucial to their work. Not surprisingly, the theory of creative problem solving and how to foster solutions in time have been part of the education of Architects for a long time. Other professions that have been facing similar problems, such as Designers and Engineers, have developed a similar understanding and integrated certain techniques in their practice, which are often grounded in experience and taught through anecdotes.

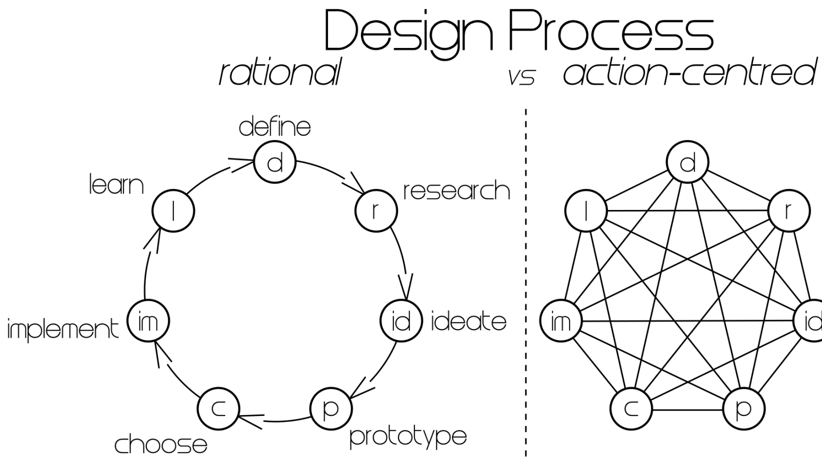


Figure 2.4: rational design process by Herbert Alexander Simon (1969) and action-centred design process taken from Meinel, Leifer, and Plattner (2011)

Since the 1960s, more theoretical approaches have been developed. Simon and Newell, two cognitive scientists, developed a theory of human problem solving which shows many connections, in theory, and in regards to the general approach, with Artificial Intelligence (AI) (Newell et al., 1958; Newell & Simon, 1972). In 1969, Simon proposed an interactive approach to problem solving called *Design Thinking*, which consisted of the seven phases *define*, *research*, *ideate*, *prototype*, *choose*, *implement*, and *learn* (Herbert Alexander Simon, 1969). In this model problem solvers attempt to optimize a solution towards a set of given constraints by iterating through these stages and until the problem is solved. This plan-driven and incremental process is distinguished from the *sequential model* by its iterative approach – the problem is not necessarily solved after the first cycle but is being worked out by repeating the cycle several times. However, this model, called the *rational model*, lacks empirical support and has been criticised for not providing an explanation for how people creatively solve problems, for example in design (Ralph, 2010). In order to solve this problem, a number of variations to this model have been developed fewer or more steps. Another approach to the design process is known as an action-centric model, which (Meinel, Leifer, & Plattner, 2011) describes. In this model the order of stages is undefined and the process is regarded as improvised and unforeseeable. This assumption is based on the empirical and anecdotal evidence that participants report actions that can be tied to one of the stages in a seemingly random order.

3 Real World Creativity

The oldest surviving text about *Eureka moments*, the famous story with Archimedes jumping out of a bath, is from an Architecture textbook (Pollio, 15/1914). In a time when book space was rare and expensive, the Roman Architect who wrote down the story gave the anecdote a fair amount of space in his seminal work. The book itself is concerned with many aspects of Architecture, including the technical ones. So why did Pollio dedicate so much space to a Mathematician pondering about the volume of an irregular shape? Especially since Archimedes had lived about 200 years earlier? While we cannot know the reason behind Pollio's lengthy account, the fact stands that this anecdote illustrates the process of creative problem-solving. It includes the original preparation for the problem and mentions that at a certain point Archimedes hit an impasse which he did not know how to overcome. Suddenly and unexpectedly, Archimedes found the solution. His joy at this discovery is described in so much detail 200 years after its occurrence, that most likely the author of the book was no stranger to the phenomenon himself. Since Galileo Galilei, scientists have been discussing whether Archimedes could have solved the problem in the described way (Hidetaka, 2016). However, Pollio's (15/1914) detailed description and the amount of space in his book dedicated to the anecdote suggests that he studied creative problem-solving as a vital part of architects' skills. The story is written in an encouraging and memorable way and gives confidence to prospective problem solvers to stay motivated even if a solution is not found at first. In short, this text might not depict the *insight* of Archimedes, but instead intends to teach Architecture students how to solve problems. Since then, pedagogy in general and the education of Architects has evolved, but it still draws from Archimedes' anecdote as an analogy (K. S. Smith et al., 2013). More than 2000 years later, I want to learn how Architecture students solve problems nowadays. If emerging solutions or *insights* were an accepted or even suggested way to solve problems a long time ago, is that still the case with today's education? How do architects solve problems?

Architects are an interesting cohort to study *insight* and the *Eureka experience*. Besides the historic account mentioned above, their problems are 'truly ill-defined' according to the classification mentioned in section 2.6.2: The goal they want to reach, often some kind of building, is unknown to them at the beginning. A set of constraints might be given to them or they define them early on during the task, but the finals solution is unknown to them at the beginning. During their education, they receive training on how to reach these ill-defined solutions, but the path itself is often ill-defined as well. Since Herbert Alexander Simon (1969)*design thinking* is used as a description of the process, but in their introduction Meinel et al. (2011, page xiv) suggest, that an ill-defined model of the process is closer to reality. Finally, the architects themselves can not judge how close to the solution they are, there is no metric to describe the distance between the current suggestion and the ideal product – they are local judges. Interestingly, the work of architects is considered to be somewhere at the boundary between natural sciences, arts, and social sciences. Nevertheless, approaching the Architects work with the terminology of Psychology introduced by Joy Paul Guilford (1967), their process could possibly be described with the terms divergent and convergent thinking: they create many potential solutions but end up at one single product. This product is also 'creative' as defined in section 2.7: it is novel within the context the building was designed, and it is useful by providing some kind of function. In summary, this suggests that the architects' process of creating might include some *insights*, and the architects potentially experience *Eureka*.

To gain a better understanding of the creative process of architects, I conducted 14 interviews with Architecture students, one group in 2015 and a second one in 2017. I asked them to tell me about their process when they engage in their task. From reviewing the literature, I already knew that the rare and fleeting subjective experience I am interested in comes with different names. In section 2.2 I discuss some of the names previously used in the scientific literature, such as *Eureka experience*, *insight*, and *illumination*. Even though the term *Eureka* originated in the Architecture literature, I was mostly aware of uses within the Cognitive Sciences. I could have based my research on one of the existing terms, but the theoretical underpinning, as well as accompanying phenomena are not well defined, as highlighted in section 2.4. Measures of *surprise*, *restructuring*, *correctness*, or any of the other elements discussed earlier in section 2.4.3 might or might not be directly related to the moment when solutions emerge. To avoid bias, for example through an availability cascade, I was interested in accounts of these experiences without defining them first. The observation of creative practitioners such as architects seemed to be a feasible approach to collect this kind of information.

Architecture, as "the art or practice of designing and constructing buildings" ("Architecture", 2018), often starts with a task to provide some utility or function. This function could be a shelter for a number of people, safety for certain activities, or any other function a human-made structure can provide. In this case, the initial question or task does not imply convergence towards a single solution. Rather, defining the problem and identifying a potential set of solutions are characteristics of these ill-structured problems, as discussed in section 2.6.2. For instance, even from a purely experiential point of view, we know that there are many different solutions to the problem of providing shelter for a family. While there is not a single answer, there are also many different ways to approach the problem, for example talking to the client, examining the local surroundings, assessing the financial backing of the project, and so on. Herbert A. Simon (1973, page 187) in his definition of well-structured and ill-structured problems, stated that the activities of "Designing a house [...] lie towards the ill-structured end of the problem continuum". These types of ambiguous problems often require greater cognitive effort (Hocking & Vernon, 2017). The mentioned anecdotal reports, as well as the theoretical features of the task thus suggest that practitioners of Architecture experience moments when solutions emerge.

3.1 Background

The moment solutions emerge is considered to be a non-repeatable, rare, and fleeting phenomenon. To capture and analyse these events I considered several types of analysis. To minimize the intervention during the process, I decided to start with qualitative interviews with students of Architecture at the University of Plymouth. I did not want to bias the interviewees with preconceptions about the nature of *insights* or *Eureka moments* but was instead interested in the validity of the answers based on their personal experience, and the depth of answers. Therefore, I decided to use unstructured interviews.

To analyse this data, I intended to borrow from Grounded Theory, which was developed to analyse interviews with dying people, also a non-repeatable event (Glaser & Strauss, 1967). As opposed to the original method, which is based on the experience of the researcher in the environment, I audio recorded all conversations. The intention was to reduce possible listening errors to a minimum. The full transcriptions of these recordings can be found in appendix 1.

After I had conducted the initial interviews with the Architecture students, Sawyer gave a presentation at a CogNovo research seminar in May 2015, where he talked about the creative process of artists. During the talk and the following conversation, it became clear that Sawyer had used a similar approach to develop a model of the creative process. He later published a slightly different analysis (Sawyer, 2016). Following the talk, I decided to analyse my data in the same way, to obtain comparable results. In this section, I introduce the emergent model Sawyer developed, as I will use it as a basis for my analysis.

3.1.1 Keith Sawyer's emergent model of creative problem-solving

In his talk *How Artists Create*, as well as his paper, Sawyer (2016) referred to two different models to explain the creative process. He introduced

Wallas's (1926) *sequential model of creativity* and compared it with *design thinking* (Herbert Alexander Simon, 1996). These models have previously been introduced in section 2.7.4 and section 2.7.5. Based on the interviews he had conducted with 9 Master of Fine Art (MFA) students from two different universities, he wanted to test which of the two models would better represent the long-term creativity of Art students during the course of a year.

In his paper, Sawyer (2016, page 6) provides four prompts he used in the interviews: "• Where did you get your idea to do this kind of work? • How did you come to this line of work? How did you come to be doing the work you are doing now? • Did you have the idea before you started the MFA program? • Is there a theory behind your work?". Sawyer recorded the interviews and later transcribed them. The parts of the text referring to the same content were then grouped into *meaning units* of a length between one and five sentences. In an initial round of reading all the interviews, he assigned short descriptions to each *meaning unit* and created a narrative from these descriptions. Based on the extracted descriptions and narratives, Sawyer (2016, page 7) developed a "set of theoretical categories that appeared in at least two of the interviews", about 22 % of his sample size. In the next step, he assigned these *emergent categories* to the meaning units of each interview. At the same time, he tested whether the categories could be collapsed, and he changed them again. The talk he gave at CogNovo must have taken place before this change because the categories he presented there were different. He then counted how many interviewees mentioned each of the categories.

Emergent categories for MFA students

The following list shows the emergent categories used in Sawyer (2016), followed by the number of artists who mentioned them. The numbers in red show the count presented in Plymouth, presumably before the final changes in categories. Also, the category *Change* was not part of the earlier analysis, while *Thesis* was. The somewhat blurry boundary between *Thesis* and *Body of work* might have been Sawyer's (2016, page) motivation to "collapse [them] into a single category".

1. Materials — when students talked about the materials used in their creations. *(8/9 mentions)*
2. Experimentation — talking about artworks no one has ever seen, which are only part of the creation process *(9/9)*
3. Accidents — events that happened in the extended environment *(6/9 4/9)*
4. Intuition — description of how artists decide to pursue a creative path *(8/9)*
5. Originality — when artists talked about the absence of novelty and creativity *(5/9 7/9)*
6. Emergence — when students talked about work that unfolded from the process *(7/9)*
7. Iteration — description of a cyclic process moving forward in small steps *(9/9)*
8. Mismatch — differences between ideas and work *(8/9)*
9. Exploration — when students did not really know why they were doing certain things *(8/9)*
10. Body of work — creating a series of artworks that are somehow related *(6/9 7/9)*
11. Change — evolution of work over time *(8/9)*
12. Thesis — the outcome of their work *(7/9)*

Connections between categories for MFA students

In addition to these categories, Sawyer discovered connections between categories by looking at which categories were mentioned within the same *meaning unit*. There are two different versions of these connections, one from the talk given at Plymouth and one from the publication.

In the Plymouth presentation, at least eight of the categories were connected. These connections are visualised in fig. 3.1. A connection between two categories means that at least one person was mentioning them next to each other. For example, one artist might have talked about the *iterative*

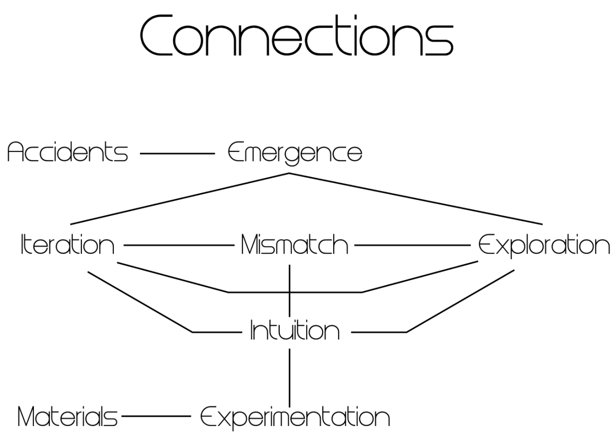


Figure 3.1: Connections between emergent categories as presented by Sawyer during his talk at Plymouth

process right after he talked about a *mismatch*; another one might have talked about the *mismatch* after she mentioned something in regards to the *exploration* category, and so on. Even more of interest could be the missing connections, for example between *materials* and *emergence*.

The connections presented in Sawyer's (2016) publication are slightly different, as shown in fig. 3.2. The additional step in the analysis changed which of the emergent categories are connected. For example, the previously unconnected *materials* and *emergence* are now linked, but *mismatch* and *iteration* are not anymore. Without discussing these changes too much in detail, it is interesting to note how the change of one category resulted in a different model regarding the connections. This suggests that the connections between emergent categories are not very stable. This further suggests that these connections are not a strong parameter to describe the created model.

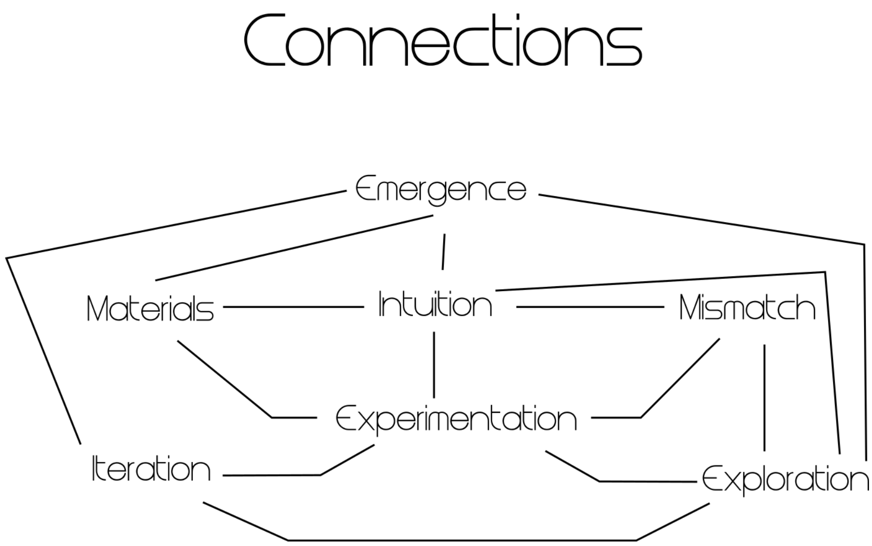


Figure 3.2: Connections between emergent categories as shown in Sawyer (2016)

The role of insight in Keith Sawyer's model

In his talk, Sawyer claimed that the categories could not be matched on the *sequential model* of creativity, but rather they have to follow the *design thinking* approach. This core finding is also reflected in Sawyer's (2016, page 16) publication, specifically where he states "there is no evidence for a linear sequence of stages". Secondly, Sawyer (2016, page 17) rejects the idea of *insight* based on the observation that none of his interviewees reported a single moment that "lead to the thesis body of work". Thirdly, the emergent category *originality* in his study relates to *meaning units* in which the artists mentioned the absence of creativity. Consequently, Sawyer suggests that the artists are not concerned with creativity.

3.2 Method

Sawyer (2016) identified three different aspects of an emergent theory: the number of emergent categories per participant, the connections between the emergent categories, and the number of participants per emergent category across the whole sample.

The analysis of the interviews follows the emergent model developed by Sawyer and previously explained in section 3.1.1. To verify the model I use coding, a technique developed for the Grounded Theory, but independent of this approach, as summarised by Gläser and Laudel (2013).

To have a comparable dataset, interviews of the same duration as those conducted by Sawyer (2016) would be required. The interviews I conducted with architects lasted between 20 minutes and 70 minutes, notably shorter than the 60 minutes to 120 minutes interviews by Sawyer (2016). However, the exact length of his interviews is not known, it is therefore not possible to assess the categories per time unit or number of words. It would not take into account the order in which questions were asked, in which interviewees structured their answers in general, and other differences between the two studies. Consequently, a comparison between the total number of *meaning units* containing an emergent category would not provide meaningful information.

I have previously presented the nature of the connections before and after the final step of Sawyer's (2016) analysis. While the exact difference in the analytic step is missing, the description suggests only minimal changes regarding one or two emergent categories. The changes that can be observed in the connections in fig. 3.1 and fig. 3.2 instead show significant differences. Some connections that had existed before vanished, while new links appeared. This suggests that the connections are not a very stable or distinctive feature of the model. Comparing it to the connections drawn from yet another sample would most likely not be useful. Furthermore, an interpretation of these changes would be elusive.

Finally, the number of participants that mention an emergent category can be extracted from both data sets. None of the studies had a time limit, which suggests that the conversations went on until the interviewees said everything they wanted or the posed questions prompted them to respond. For example, if they mentioned *iteration* in both cases, this would suggest that it plays an important role in these cases. If something was not mentioned during the interview, it might have been of lower importance for the creative process. The number of participants, or rather the number of participants who mentioned a certain category, should provide some ideas about which categories were less or more important.

3.2.1 Participants

Fourteen interviews were conducted in the years 2015 and 2017 with second and third-year students from an Architecture project-based tutorial. The first six interviewees in 2015 were selected by the tutor of the course. The tutor selected the students based on their performance, identifying the ones who could reflect on their creative process better. Three of the students were second-year students; three were third-year students. The interviews took place right after I introduced myself to the group of selected students. During each interview, the student, myself, and Katharine, a lecturer in Architecture from my supervisory team, were present. Katharine's role was to facilitate the interview by providing a common language, for example by explaining the design process and describing technical terms.

The recruitment process for the interviews that took place in 2017 was different: I went to the tutorial, introduced myself as a researcher interested in the process of creative production, and asked students to volunteer to participate in some interviews by giving me their email address. Over the following weeks, I contacted the ones who gave it to me and arranged meetings. In these interviews only the student and I were present. Out of the 38 initial contacts, seven interviews were conducted.

3.2.2 Interviews

The interviews were conducted as unstructured interviews. This form intended to mimic everyday conversations and therefore reduce any power imbalance between the interviewer and the interviewee. Besides, the interviews were conducted in settings that were meant to make the students feel comfortable. With the consent of the interviewees, the conversations were recorded on mobile audio recorders. In 2015 the interviews took place in a visually separated space in the studio as this was familiar and comfortable for them. As a result of the interviews taking place in a more natural environment, only four of the seven recordings could be transcribed due to technical issues and noise levels. As a consequence, the interviews in 2017 were moved to a quiet place in an on-campus cafeteria, which still provided a natural and comfortable environment for the students.

The questions were posed in an open-ended form. The opening question was intended to frame the whole conversation by asking the students "how do you create?" Subsequent probes were used to encourage the interviewees to talk about their processes without biasing them towards answers. During the conversations, I encouraged them with minimal feedback, such as nodding, 'mhm', and 'm'kay'.

Unstructured interviews have several advantages; however, the following should also be kept in mind: when they are intended to make the interviewee reflect on a long process, ethnographic interviews are not capable of collecting all the information about it, nor do they reveal its exact order. Therefore, not everything the artists and architects experienced might have been mentioned in the interviews. Looking back at a long period, not everything might have been mentioned in the right context. Also, mentioning something in close approximation to another topic does not necessarily reveal temporal or experiential proximity. All interviews are also biased by social desirability. In both professions, Arts and Architecture, the *design process* is often part of the curriculum and taught as a technique to be creative. Since more creative practitioners are considered to be more successful in Arts and Architecture, this creates an attentional bias during the process, but also a confirmatory bias when reporting the results. Since the participants in the study by Sawyer (2016) were able to get their name and professional websites published in the study, the interviews could be seen part of the oeuvre itself, as the artists were given a chance to present themselves desirably.

3.2.3 Architectural terminology

The architects frequently use terms that are familiar to them, but not necessarily to the reader of the transcripts. The students are part of a project-based *tutorial* running over the length of a whole semester. They have 24-hour access to the *studio*, which acts as their workspace and often also as their social space during this time. The tutors are available for questions during work days and give presentations and conduct exercises about twice a week. The *tutorial* consists of several *projects* or tasks, typically running for two to three months. At the beginning of each *project*, the tutors give the students a *brief*. This *brief* is given as a talk and students also receive a print-out. This *brief* contains information about a location and a goal to achieve. In 2015 these locations were a neighbourhood around Exeter Quayside and a harbourside at Plymouth Devonport. In 2017 all students worked in a neighbourhood around Plymouth Derry's Cross. Within that larger area, students then identify a *site* they were going to work on. Some students referred to the whole area introduced in the *brief* as a *site*, others used it specifically for the location of their projects. Within the *tutorial*, students work in groups. At the end of the tutorial, each group has to present their work, consisting of a *master plan* for the whole area as well as individual projects within the area. They are graded for the group work as well as for individual contributions. For the *master plan* as well as the individual *sites*, students have to develop a *programme*, which represents some idea on how the space is going to be used. These *programmes* need to answer the questions posed in the *brief*.

To complete the project, students use different styles of architectural drawings. *Site plans* and *floor plans* show the whole context a building is situated in or an individual level of a building from above. Often students refer to these drawings as *plans*. *Cross sections* or *sections* are vertical cuts through a building or site. *Elevations* are drawings of the façades or walls of a building, showing, for example, the west *elevation* of a building. A *projection* is a three-dimensional representation of the building, for example from an isometric, axiometric, or, in one case, 35 degrees perspective. In addition, students use *models*. *Physical models* are either built from 3D-printed objects, paper, wood, or cardboard and can be touched and moved around. *Virtual models* or *digital models* are computer-based models using *Computer-aided design (CAD)* software such as *ArchiCAD*, *SketchUp*, or others. The students are encouraged to use *sketchbooks* to communicate visual aspects with the tutors, clients, and colleagues.

3.2.4 Interviewed architects analysed

From the conducted interviews, I intended to find evidence for the similarity between the creative process of artists (as reported in Sawyer's (2016) study) and architects. In the analysis, I followed a similar approach: from the recorded and transcribed interviews I marked *meaning units*. Since I did not intend to create a new theory but instead wanted to confirm an existing one, I adapted the *emergent categories* from Sawyer (2016) and assigned them to the *meaning units*. Since the length of interviews between the two studies differed, the total number of meaning units were not compared.

3.3 Interview summary

This section examines the conducted interviews individually. In accordance with the ethical guidelines for the study, the names of the participants have been changed to protect their privacy.

3.3.1 Joshua Watts

Joshua was interviewed first. I started by asking him how he solved problems. This led to a discussion on how to identify the problem in the first place. Starting from an illustrative example, I led him to identify the exact part that turned this description into a problem, but he could only describe it as a 'personal analysis'. Later in the interview, he named the form of the final presentation as the only constraint. Part of that analysis involves getting a feeling of the site, based on personal experience as well as studying the history of the site. Following a description of how to get this feeling, Joshua proceeded to talk about the changes he had planned for the site and the motivations behind them. I then asked him to elaborate on these motivations, and he described the goal of the architecture training to be to test ideas that might not actually 'be viable in a real world', but rather to learn how the 'design process' works. He described the whole process incrementally, as a continuous work developing throughout the year. Nevertheless, part of this incremental process are occasional 'clicks' that spark an idea.

After an initial idea, he described the process as very steadily flowing, from 'sketchy designs' to refined drawings, until the building is complete. From this point on, the scaling down allows to design some details that help put different parts together and to understand how all these parts work in unison. As opposed to a model, drawings are used to describe the functionality of a house, while the model gives an understanding of how it will look at the end. Even though he personally disliked models in the past, he admitted that they work better for communicating an idea to others. He even got to consider models as useful tools for his work, comparing them to 'still frames'.

3.3.2 Ewan Palmer

Ewan quickly identified the problems he had to solve as the ones assigned during the tutorial. He gave the example of a '1500 square metre building that has to have at least two floors. Starting from this, he tried to internalise the problem ('try to think') before he started drawing everything out on paper. This was followed by an iterative process of refining the drawings and plans. Asked about the initial inspiration, he talked about the surroundings and the initial visit to the site, but also about how other memories seemed to play an important role. The older the memories were, the less likely he was to quote them as an inspirational source.

Ewan had been working on the Exeter quay. His main idea was to assess safety concerns and to integrate the site into the city. He was looking at the positive and negative aspects of 'stitching things back together' and its implications for gentrification and other social issues. Rather than designing the building itself, he tried to face the problem on the social level by enabling residents of that area to amplify their agency and influence on the architects and designers who were physically shaping their city. The main problem he identified was that the city was not verbalised in a way that was focused on the inhabitants; instead of buildings, he was trying to foster connections between people in different roles.

He admitted that the process was not a smooth experience. He described it as progressing in jumps and plateaus. On a plateau, he would try to sort things out in details but then, all of a sudden, a jump to the next 'plateau' would happen. He recognised the plateaus as a necessary aspect of the 'making process' to ease ideas out of his mind and into the physical world. He also believed that he had to find the right medium to be able to make the next jump. The most important step in solving a specific, smaller problem in his work seemed to be identifying the right medium. He claimed that the right medium could only be identified afterwards, once he found the solution using it. When the right solution appeared, it was accompanied by a feeling. He recognised that a solution might be different for everyone trying to solve the problem. So the solution is not inherent, it is rather its perception that makes it the right solution at the right time. Even though the process was described as a crucial part of the solution, Ewan always tried to use the medium which he thought would be most likely to reveal the solution.

When asked about working in groups, he answered that for him working in bigger groups was more interesting, although the smaller the groups are, the easier it is to solve problems; stemming from this, working individually made it easiest to solve problems.

3.3.3 Alex Wells

Asked what might be a problem in architecture, Alex answered that he did not recognise a problem at the beginning of a project. He described this very subjective process as looking for 'a quality which is uncertain', as identifying and highlighting a potential problem. This uncertain quality could be anything in a community or landscape, something that is almost intuitively recognised by the architect. According to Alex, this recognition could present itself in two ways, which he calls 'through inspection' and 'back to nothing'. 'Through inspection' seemed to relate to an incremental, analytical approach, which he called 'juggling'.

Asked about the second approach, the 'back to nothing', he elaborated that it involved him being stuck and then 'accidentally' receiving external input that would show him a different perspective on the project. He called it 'pure coincidence', an example of which could be talking to someone. He admitted that this happened rarely and only if he got trapped in a dead end. His normal process seemed to be the juggling one, where he played around with different ideas and processes until the problems were solved. During this juggling, an accident might still occur – in which case he would exclusively work on the accidental idea.

The juggling process seemed to be quite frustrating and not as rewarding as the accidental approach. But since he knew the nature of that process, he accepted it. He would change the medium and the object of his work frequently, and each of these switches would lead to something new and unexpected. Working on only one medium or object was quite frustrating for him, since he was conscious about the discursiveness of his current work as well as the amount of time and effort it took; instead, changes to the work process were welcomed, since these meant a change in the project and medium as well. Overall, this process was described as progressive and iterative.

Accidents were more rewarding, but they only happened a few times a year. These accidents were mostly triggered by outside events, like reading or watching something unexpected. He gave an example for this from the previous year, when he went to a lecture that was not connected to his current work but that allowed him to see, all of a sudden, the solution for one of the problems he was engaged with. He 'saw all the floors in my design at the same moment', but it took him a few months to get back to the idea and verify it. However, he considered this example to be rather small. As a large scale example, he described a coincidence that happened to some architects and a big company. In this anecdote, the architects designed a building that was by accident formed like an Asian letter symbol.

Alex described the change of medium as a helpful tool, similar to translating something between different languages. Each of these 'translations' might help to find or identify a problem. Besides models, drawings, and computer tools he mentioned 'writing about the space' as another medium. Whenever he did not have a clear vision of where to go, he would start 'working' by making drawings, models, and talk to people. However, he was not certain about the 'hierarchy' of the flow of work. This flow or process was the real knowledge that he acquired through practice. He believed that education and upbringing would influence the work as well. Regarding inspiration, he would try to get it from other people – not necessarily professionals in the field, also people coming from outside the area, who would sometimes be even more efficient and enjoyable.

At this point, Katharine shifted the conversation back to the process and the skills required to complete a full process. She also mentioned that there are differences between individuals and the processes they go through. Alex agreed. According to Alex, the tutors played the same role as the laypeople he could potentially speak to. He also acknowledged that they pushed him outside of his comfort zone and made him think in new ways.

3.3.4 Kiera Stanley

Asked about the problem-solving process, Kiera described it as follows: since the problem is not tangible, she would build on an inspiration that she got from somewhere else. She described this inspiration as a motivation to work on the project for a while until she hit 'the next wall'. Then she entered a phase of constantly thinking about the project, which led to generating a large number of ideas. Once she had these ideas, she concentrated on expressing them on paper. The idea generation could be accelerated by working out, by running somewhere random or even by visiting the site she was working on – but without consciously thinking about the problem. Regarding the site, she was working on bringing some meaning into it. Therefore, Kiera thought that a good idea was worth more than having just a good design.

Kiera considered the 'meaning' she wanted to bring back to the site as something personal, which would give another reason for people to visit the site other than its pure functionality, something that would spark local interest. History was another inspirational source for her, and she tried to reconnect the space with its past. She also drew from ideas she developed in previous years and saw the problems as a possibility to increase her own skill set. Regarding her skills, she talked about different stages that she could reach.

Kiera assumed that building her skill set would also help her generating ideas since she would eventually become quicker at presenting concepts and taking notes of ideas that would emerge during conversations. This was especially helpful since she considered time and deadlines to be the main constraint within the tutorial. On the other hand, she claimed that deadlines helped her to generate more ideas: with a deadline approaching, she would prototype several ideas and select one to follow up. The selection of the best idea was made with the help of other people and by taking different perspectives. Therefore, working in a group helped her to arrive faster at the results since she was quicker in selecting better ideas. Groups of professionals seemed to be more helpful for her than laypeople.

3.3.5 Lewis Vaughan

The interview with Lewis started by asking him about his creative process, but he immediately responded that he might be one of the worst examples of it. He explained that he suffered from anxiety and stress at the early stages of the process, that he would often jump between different suggested stages of the design process, and he would finish the work just before the deadline. With a background in Graphic Communication and Art, he emphasised the creative aspect of his work, as opposed to having a neatly organised sketchbook that communicated it. He depicted himself as a 'Mad-Hatter' regarding his work style, scribbling and drafting many ideas and understanding the problem through this process. He could not identify the source of his ideas but used the metaphor of bubbles that grow until they suddenly burst. Lewis thought that, particularly during abstract work, supposed accidents are often and at distinct moments identified as useful contributions to a design. Good and bad ideas are identified through a feeling rather than a defined test.

He believed that understanding a site and a problem relies on personal experience and individual engagement with the task. As an example, he suggested that his parents' house would probably be the best site for him since he had experienced it quite extensively. This also reflected in his work, where he considered social, ecological, and economic factors. He applied his knowledge and influences from the environment in new combinations to his work. However, external time constraints define the end of the work, albeit he could produce a much more detailed project if given more time.

3.3.6 Bailey Watson

Asked about his creative process, Bailey provided a basic timeline of how he approached a task or 'architectural problem'. Through communication with his peers and immersion in the site, he identified elements which he considered to be working or not working. He also drew on external knowledge and, by doing so, reported surprising and sudden re-combinations of concepts he found in different places. In particular, he mentioned 'happy accidents' and elaborated on how they could help in the design process.

Bailey worked on several media in parallel, as he believed this to help him overcome impasses. For example, he would do physical and virtual modelling while drawing at the same time. Similarly, communicating with colleagues and laypeople, and taking the perspective of non-Architects, helped him solve the problems at hand. To understand the problems, he would draw on personal experience of the sites, but also on his work experience outside the academic setting. He described how, in one of his previous projects, he was working as if in the flow, with answers being 'there', ready to grab and apply to the project. He tried to recreate a similar environment for his current group but ultimately failed in doing so.

3.3.7 Charles White

Charles started by talking about his process of creation, mostly in terms of deadlines and external pressure. He would scribble and draft ideas for a very long time until finally the time to submit his work came. Then, at a certain moment in time, when he could clearly visualise the end product, he started producing visible output.

He approached his current task from an experiential point of view, spending time on the site and doing research on its history and current usage. Drawing from visual imagery such as the Wild West and buildings crumbling away in the back, he developed the idea of a walled garden. This idea led to further developments, which were multimodal, strongly relying on sound as well as vision. His project space was developed as a journey.

3.3.8 Zak Walker

Zak explained the development of his current working style in detail. Drawing on experiences from the previous years, he argued for a very structured and almost algorithmic approach to generate the final design. He stated that six iterations seemed to be a good number for him; if during the problem-solving process he had not tried six different approaches, he would try once more; if he had tried more than six, he would test it and only then proceed to the next iteration. This clear approach means that the moments when he switched between different scales and media was predictable. He even explained the order of scales and media he used. From his explanation, it seemed that he had developed the order and working plan himself, possibly driven and influenced by the tutor, but seemingly based on his own experiences. Interestingly, he mentioned that, while the use of automated processes to produce models would reduce his workload, it would also alienate him from the current iteration. Therefore, for him working on drawings or models by hand might seem slower at first, but could be beneficial in the long run.

In his work, Zak considered the task as a constraint, in particular, the constraint was identified in finding the task from the ill-defined question posed in the brief. Another constraint he mentioned was the technical requirements, although this is introduced at a later stage, possibly triggered by the looming project deadline. Again, he worked on these problems in a very structured and defined manner. These requirements also extended to requirements from the course as well as his career ambitions. Interactions with other people were not very fruitful for him: neither communication with non-Architects nor with his colleagues in the group seemed to help him advance. On the contrary, they seemed to be 'a little bit of a hindrance'.

3.3.9 Peter Kemp

Peter started explaining his project by referring to the history of Plymouth and the setting the project was situated in — who was the client, who were the beneficiaries, etc. The problems he had observed and wanted to address were a direct experiential result from this. The group developed through many iterations, and this seemed to be an ongoing process. The individual process was being developed in clearly defined steps, from initial sketching to building different types of models. Each of these steps was tested individually, but the feeling towards these temporary solutions played a role on which step to take next as well. Which medium or scale he uses seemed to rely on his feeling and experience.

Peter's ideas were based on previous attempts, on curiosity, and on identifying several candidates for the solution. For example, the previous night he had been working to create a few models that he knew would not make it into the design, but that might lead him to generate a whole new idea. Peter appreciated the external constraints of a deadline since any project could be made more and more optimal over a very long time and many iterations. Yet, at some point, the output does not improve noticeably. Finding that sweet spot is the difficulty of the creative process. When working on a problem, he was aware of the difference between him as a designer and the audience for his project. Even more, he took into account societal and ecological aspects as constraints and suggestions for the development of projects.

3.3.10 Amelia Gardiner

Amelia had a very structured approach to solving Architecture problems. She started spatially far away and then, during the process, zoomed in. Once she solved the problems that could be solved on a certain scale, she moved in closer. After finalising the details and assuming to have finished, she would run one final test on the largest scale, one more time. Within each scale she would use different techniques, starting with drawings, then computer models, then physical models. To move from one technique to the next, she would need to be 'certain', and she would need to understand the experience of people interacting with the space, and to have an idea about how to progress. Accidents and chance were regarded as a disturbance in her process rather than a help.

The ideas Amelia used in her design were grounded in personal experiences at the site. With those experiences, her group started a discussion to find a theme and a solution. She was aware of the role each person had within her group, and she would use their experience to bring further the group design and consequently her work.

3.3.11 Spencer Barnett

For Spencer, any aspect of the project was about the personal experience. It started with an understanding of the site with which Spencer had interacted before the project. In a subsequent step, his group visited the site and talked to the locals or even just observed them infer what their intention and requirements were. While working on a project to design a library, Spencer was guided by his own requirements: cosy sofas for novels with a coffee in hand, hard chairs and hard tables for essay writing. Finally, the whole creative process seemed to be inspired by his previous experiences and interactions with his peers. Problems were identified through personal experiences, such as the light shining through the car park and the dead space.

The ideas Spencer used for his design were largely based on a mental image of existing 'libraries in America', but enriched by elements and ideas seemingly taken from other sources such as books and films. Furthermore, errors and faults introduced for example by hand drawings were utilised as part of the process to generate ideas. In another example, he relied on the material available from a tool, in particular, the order in which material was available in a piece of software. The selection process seemed to be based on personal preference and perspective taking. He attributed the selection process to tacit knowledge and to the experience accumulated through training and exposure. This was also the reason he chose to take part in the study.

3.4 Results

The following paragraphs report one link per participants from an *emergent category* to a *meaning unit* in the transcripts of the interviews. Because of the different length and other differences between the interviews of art students and architecture students, the numbers of meaning units per students were not comparable. As argued before, the number of participants that mentioned one of the *emergent categories* in their meaning units, remained a comparable measure. Hence at least one link per student is reported here.

Nine of the students explicitly name paper or cardboard as material (see appendix 1.2 line 12, appendix 1.4 line 13, appendix 1.5 line 93, appendix 1.7 line 18, appendix 1.8 line 219, appendix 1.9 line 119, appendix 1.10 line 114, appendix 1.11 line 103), all of them mention some kind of material for their sketches, (virtual) models, or other forms they are working with (other materials see appendix 1.1 line 76, appendix 1.3 line 95, appendix 1.6 line 84). Material: 11/11

All of the students talk extensively about Experimentation they are taking to reach the final product: 11/11 (see appendix 1.1 line 38, appendix 1.2 line 17, appendix 1.3 line 33, appendix 1.4 line 109, appendix 1.6 line 36, appendix 1.5 line 94, appendix 1.7 line 221, appendix 1.8 line 38, appendix 1.9 line 218, appendix 1.10 line 16, appendix 1.11 line 109).

Accidents were an important part of the interview with Alex, but Bailey, Amelia, and Spencer talked about it as well (see appendix 1.3 line 22, appendix 1.6 line 81, appendix 1.10 line 191, appendix 1.11 line 395). Accidents: 4/11

When it comes to decisions on what to do next, which medium to choose or how to approach a problem, most students students agree that they have not a logical, but rather a intuitive approach to it (see appendix 1.2 line 15, appendix 1.3 line 10, appendix 1.4 line 9, appendix 1.5 line 97, appendix 1.6 line 78, appendix 1.7 line 127, appendix 1.8 line 262, appendix 1.9 line 311, appendix 1.11 line 339) Intuition: 10/11. For Amelia, who did not explicitly talk about intuition, the change of material seems to follow a predefined order, but she did not comment on the time or the condition when this happens.

Originality was mentioned only by Spencer (appendix 1.11 line 32). Lewis in his interview talked about creativity instead, referring to originality of the work as well (appendix 1.5 line 23) and Charles explicitly mentions being inventive (appendix 1.7 line 183). Interestingly, the three students talk positively about originality, as opposed to the artists in Sawyer's (2016) interviews. Originality: 3/11

All approaches were driven or had influences that were coming to the work from the process itself. Some mentioned the change in scale (see appendix 1.1 line 60, appendix 1.3 line 84, appendix 1.4 line 51, appendix 1.9 line 323, appendix 1.10 line 123) others onlyt the change in medium (see appendix 1.2 line 106, appendix 1.6 line 78, appendix 1.8 line 49) from which solutions emerged. Even others did not connect it to any changes, but acknowledged the emergence of a solution (see appendix 1.5 line 168, appendix 1.7 line 185, appendix 1.11 line 116) Emergence: 11/11

The architectural way of solving problems seems to involve increments, at least in the way it is taught in Plymouth. Therefore all students mentioned Iterations: 11/11 (see appendix 1.1 line 59, appendix 1.2 line 18, appendix 1.3 line 49, appendix 1.4 line 11, appendix 1.5 line 164, appendix 1.6 line 77, appendix 1.7 line 257, appendix 1.8 line 58, appendix 1.9 line 96, appendix 1.10 line 136, appendix 1.11 line 126).

Alex talked about an idea he had during a previous project or stage of a project that he couldn't include in his previous work (see appendix 1.3 line 79). Also Kiera (see appendix 1.4 line 80) talked about a mismatch between things she wanted to achieve in the previous year and that she used that knowledge to create some elements in this years project. Other examples are appendix 1.5 line 156, appendix 1.6 line 128, appendix 1.8 line 206, appendix 1.9 line 61, appendix 1.10 line 8, and appendix 1.11 line 318. Mismatch: 8/11

When Ewan chooses a medium, he is rarely sure that it is the right one (see appendix 1.2 line 15). He will only know afterwards (see appendix 1.2 line 109). Most of the other students report similar explorative steps: (see appendix 1.3 line 46, appendix 1.4 line 17, appendix 1.5 line 94, appendix 1.7 line 19, appendix 1.8 line 20, appendix 1.9 line 218, appendix 1.10 line 61, appendix 1.11 line 159). Exploration: 9/11

Almost all students talked about their body of work (see appendix 1.1 line 39, appendix 1.3 line 74, appendix 1.4 line 81)(appendix 1.5 line 78, appendix 1.6 line 116, appendix 1.7 line 47, appendix 1.8 line 92, appendix 1.9 line 207, appendix 1.10 line 51, appendix 1.11 line 363) Body of work: 4/11

Less than half of the Architects talked about the current work as a result of the changes in the past, or were projecting their work into the future (appendix 1.5 line 96, , appendix 1.6 line 23, appendix 1.8 line 95, appendix 1.9 line 125, appendix 1.11 line 334). Change: 5/11

The final presentations and the constraints that go along with them were named by less than half of the students (appendix 1.1 line 127, appendix 1.4 line 80, appendix 1.6 line 259 appendix 1.10 line 67, appendix 1.8 line 441).

This *emergent category* was only part of the talk, not of the published paper, it represents an earlier stage of the emergent model by Sawyer. Thesis: 5/11

During the assignment of *emergent categories* on the *meaning units*, one more category emerged from the text: *insight*. It is not only the center of my interest within this thesis, but was also mentioned by three interviewees of my sample and therefore complies with the rule imposed by Sawyer (2016) on when to include an *emergent category*. *Insight* is considered a discrete step as opposed to a continuous process and sometimes referred to as a cognitive leap (also see section 2.2.2). Lewis in his interview talked about jumping between steps of the process (appendix 1.5 line 95), which could be a weak support for a non-continuous process happening. He further talks about "bubbles, which burst" (appendix 1.5 line 160). Bailey talks about the best decisions made away from the task, "doing random stuff" as he puts it (appendix 1.6 line 47). Later he talks about another moment of potential insight when he identified an idea he could transfer from a Barcelona fish market to his current project (appendix 1.6 line 53). Potentially this and another accident that happened later in the interview could be considered a serendipity as well, in any case they seem to be discrete cognitive leaps (appendix 1.6 line 86). Charles, when he talks about how they developed the idea of the walled gardens, explicitly mentions having and *Aha moment* (appendix 1.7 line 74). Zak, on the other hand, mentions that ideas "began to click" with him, another figure of speech sometimes used for *insights*. Insight: 3/11

Category	MFA talk	MFA paper	architects
Material	89 %	89 %	100 %
Experimentation	100 %	100 %	100 %
Accidents	67 %	44 %	36 %
Intuition	89 %	89 %	91 %
Originality	56 %	78 %	27 %[1]
Emergence	78 %	78 %	100 %
Iterations	100 %	100 %	100 %

[1]Originality was mentioned in different context: Sawyer's (2016) students mentioned the absence, while students in my study referred to creativity in a postive way

Category	MFA talk	MFA paper	architects
Mismatch	89 %	89 %	73 %
Exploration	89 %	89 %	82 %
Body of work	67 %	78 %	37 %
Change		89 %	45 %
Thesis	78 %		45 %
Insights		0 %	27 %

Table 3.1: The ratio of students that mentioned one of the emergent categories in the data set presented in Sawyer's talk, Sawyer's (2016) paper about MFA artists, and my interviews with architects. The text marked in red were only part of Sawyer's talk, but not of the publication. Insight is the twelveth emergent category that was mentioned regularly in my interviews. It was not part of Sawyer's (2016) analysis, but he concludes that insight is not part of the creative process.

3.5 Discussion

Bearing in mind the different methodology, the different sample group, and the different aim of the study, it is striking to see the similarities in the results as shown in table 3.1. In both studies, *accidents* are mentioned by only a few interviewees. Conceptually similar to *serendipity*, they might not be considered as part of the problem-solving process, but rather as a precursor. As discussed in section 2.2.7, a *serendipitous moment* is often perceived as part of the problem finding process. Another explanation is, that these 'happy accidents', as one of my interviewees called them, happen rarely. Even though the interview I conducted aimed at discussing the creative process as a whole, many of the interviewees drew on their recent experiences. Some of the projects had just started a few weeks prior to the interview and *accidents* might not have happened in that time window. This would also explain a similarly low number of interviewees who mentioned *insights* in their explanation of the creative process in my interviews.

Initially, the number of students who mentioned *originality* was similarly, with just about half of the students as presented in Sawyer's talk. In the later analysis in Sawyer's (2016) publication, the ratio increased. Nevertheless, it is interesting to note that the participants in Sawyer's (2016) study referred to their work as not being *original*, while the architects in my study referred to *originality* and *creativity* as positive features. Overall none of the artists from Sawyer's (2016) cohort mentioned *originality* as a contributing factor and only a low number of participants in my interviews. It is interesting to follow Sawyer's (2016, page 17) thought that "originality is a defining element of creativity. And yet, these artists are not concerned with originality". This goes back to the discussion of where novelty and originality are defined, as discussed in the context of historic and personal creativity in section 2.7. A creator does not necessarily need to identify them or aim for novelty; it is rather for the audience to decide this. Since the participants in my study often take the position of future users of the building or immerse themselves in the context of the site, this would explain why more architects identify originality in their work than artists, for whom the audience is maybe less defined and may be of less importance for the work itself.

The difference between the ratio of students mentioning the categories *body of work* and *change* is notable as well. Fewer architects are concerned about how their current project fits into their whole body of work. Potentially this difference can be explained by the participants in both studies. The artists interviewed by Sawyer (2016) were working on their final presentation for a Masterclass. To be accepted in the course, they needed at least four years of art education with a Bachelor degree and were selected based on a previously submitted portfolio. Most of them had professionally been working as artists, had worked in the field for several years, and intended to keep working as artists. This explains a strong focus on the changes they had experienced during the past years of creative practice, but also their interest in creating a consistent and outstanding oeuvre. On the other hand, the Architecture students interviewed for my study were participating in a Bachelor course. For second-year students, it was potentially the first project-based work, while third-year students had more formal experience, and some of them were already working as architects. With less background, there was also less focus on the learning experience from previous work. One way to assess the work of an architect is through their realised plans. The plans of these tutorials, on the other hand, were only aiming at getting grades from the school of Architecture. Good marks were, therefore, presumably more important than how the current plan fits into their previous work. Asked about their future plans, some of the students mentioned planning going on to Master and PhD studies. It would be interesting to interview students and practitioners at that more advanced level. Possibly these results could show an emphasis on the *body of work* and *change*, similar to the results show by Sawyer (2016) for Masterclass artists.

Interesting, especially in the context of this work, is the absence of *insight* in the interviews by Sawyer (2016), while at least some I interviewed mentioned these *Aha moments*. This could have two causes. Firstly, for Sawyer (2016, page 17) an *insight* is one single step leading to the solution. He writes: "These aspiring painters never report a moment where they have a single major insight that leads to their thesis body of work." This reflects the definition of *full insight* but does not take into account *partial insight* as introduced in section 2.4.1. He further states that "rather, they report an extended process of working, during which small ideas that may or may not lead toward the final work emerge unpredictably" (Sawyer, 2016, page 17). He classifies these small ideas as part of iterative design process. Nevertheless, these small steps could very well represent *partial insights*, as previously discussed in section 2.4.1 and section 2.7. Secondly, the absence of a phenomenon in the interviews do not equate to the phenomenon not taking place. It could either be essential as breathing, happening sparsely over the whole process, or not being considered as part of the process, as previously discussed for the *accidents*. Overall, a conceptual difference and the missing reports from the interviews does not provide a strong argument to conclude that there is "little support for the theory that the essence of creativity is an original insight" (Sawyer, 2016, page 18).

The following paragraphs discuss the content of the interviews by taking the methodology into consideration. A novel multi-layered model emerges from this discussion. Finally, a conclusion is drawn.

3.5.1 Keith Sawyer's emergent model as sequence or cycle

From the data Sawyer collected in the interviews of Art students, he created a theoretical model of their creative process.

It is easy to connect this emergent model to the *design process*: All interviewees mention *iteration*, one of the fundamental principles of the design process. Closely related is the category of *experimentation*, when they try new techniques or ideas, potentially as one of the iterative phases. The selection of the *materials* for the next iterative phase might be *intuitive* or through random *exploration*. Later in each phase, solutions or ideas might *emerge*, potentially showing a *mismatch* during testing. Based on these intermediate results, interviewees choose their next iteration based on their past experience (*change*) or with the *body of work* in mind. In this iterative cycle of predefined steps, there is little room for *originality* or *accidents* as a productive input. The emergent model is, therefore, consistent with the *design process*. How about the *sequential model* of creativity?

In the context of a *sequential model*, the emergent model by Sawyer (2016) could be mapped as follows: During the initial preparation for the problem, artists choose the *material* and start *experimentation* and random *exploration*. During the incubation phase, *intuition* and *accidents* help to break the impasse, possibly through a *mismatch* that results in restructuring the problem. The solution *emerges* during the intimation and illumination phases and is potentially *original* and an *insight*. During the verification phase, the artists contextualise the new solution within their past experience (*change*) and the whole *body of work*. The only category missing so far is *iteration*. The interviews cover a time of several months. Within that time, the artists were most likely creative for more than one goal. Naturally, the steps they took to create new output is similar to the ones they did before. Therefore the subjective experience of the artists might be reported as *iteration*. Even more, if each bigger task, such as creating a new painting, is broken down into smaller subtasks, such as creating a background or the overall composition, then the artists repeat the *sequential model* regularly. Finally, the Master's course or even the generation of the *body of work* could be seen as overarching *sequential tasks* by themselves. It is therefore possible to map the emergent model from Sawyer (2016) onto the *sequential model*. In the next section, I discuss some implications of observing several sequences.

3.5.2 Towards a multi-layered model of creative problem-solving

In the previous section, I introduced the idea of several *sequential models* of the creative problem-solving process contributing to the work discussed in the interviews. Here the assumption is that architects work on more than one topic and more than one problem within the same observed time period. These problems might be connected or in some cases seemingly disconnected. These several problems are a result of the interviewees dealing with the complexity of a substantial problem, given during the brief of the tutorial. At any moment in time, the architects might consider only aspects of this task, for example, the context surrounding the building, the intended function, the aesthetics, sound, or measurements. They address these partial problems in sketches, models, 3D visualisations, writing, or by talking about it. Through the representation of partial problems and their neighbouring issues in the same medium, for example by sketching an acoustic and social aspect within a single scope, two previously disjunct approaches overlap. This recombination might solve one of their sub-tasks or create new problems. The media, such as sketching paper or models, act as externalisations of the cognitive processes (Pearson & Logie, 2014). While the architects focus their attention on one specific aspect of the task, other elements are often close by or part of the same medium. For example, when tracing the path of a piece of paper through a printing house, the architect becomes aware of spatial requirements for machines and potentially the soundscape. This awareness, which comes with the acknowledgement of constraints and requirements of other subtasks, might not be the primary focus but rather unconscious. If they can integrate different perspectives into one medium, this might solve an umbrella task, and they might be able to continue to another aspect of their overall work. Otherwise, a change of medium, material, or scale apparently helps in overcoming this type of impasses.

The change of medium, material, or scale can be seen as approaching the problem on a different hierarchy, possibly either a higher or a lower level of abstraction. By changing the medium, architects are required to rethink the current issue in different terms. By changing from a two-dimensional sketch to three-dimensional modelling, another spatial dimension is added. This requires new constraints to be taken into account and, as a result, generates a higher order generalisation of some of the problems. At the same time, some of the thoughts are materialised and do not need to be added each time the architect looks at the idea, therefore potentially freeing some cognitive capacities. While producing the model, some problems are solved through the process itself. Arguably the model serves as an external cognitive device expanding the architects' capacities of processing all available information, in particular regarding the transition between dimensions. The change of material, for example, if the architect decides to exchange a wooden wall with a brick wall, is another way to generalise. This change of material as a technique results in rethinking a certain area in the building. Here the conception alters from having a structure of a certain type of wood to a more general idea of what the purpose a wall, staircase, or floor might serve at this position. It shifts the architects' attention to higher level abstract thinking, from which they can potentially traverse down to a number of concrete implementations of the abstract idea. Finally, the change of scale, for example by zooming out, reduces the details on each of the elements, therefore forcing architects to simplify concepts. This enables them to shift their thoughts to a higher-level of abstract thinking as well. Conversely, the zooming in requires specification of formerly abstract ideas into concrete implementations.

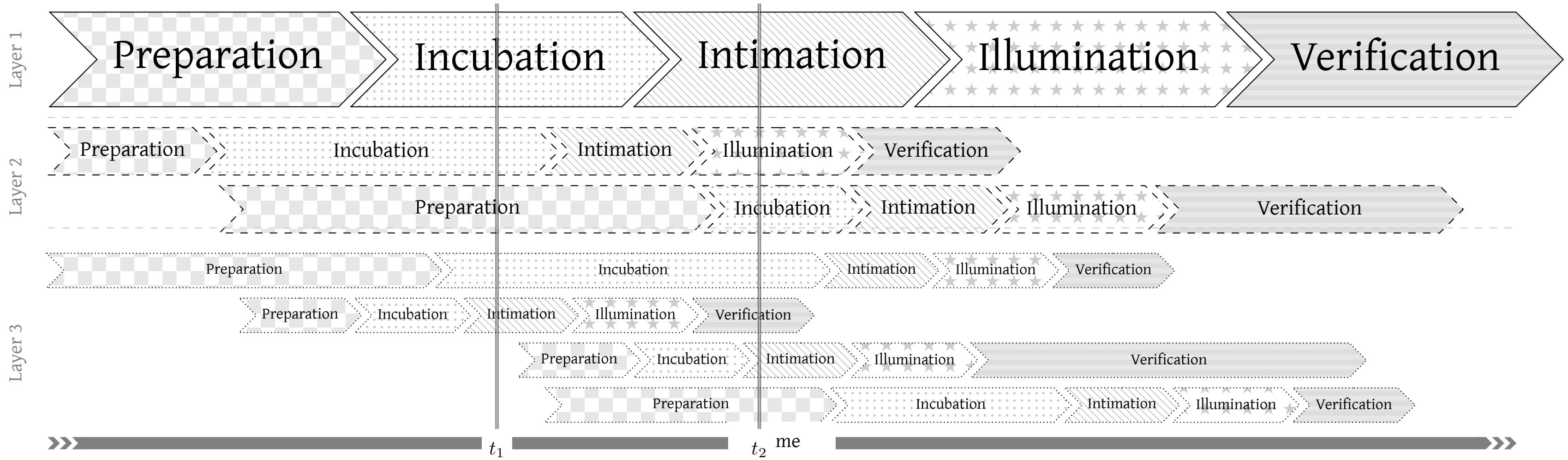


Figure 3.3: Multi-layered sequential problem solving, in this example with three layers. Each problem solving process is sequential in itself, but some lower level processes contribute to a higher task (eg. preparation of the 2^{nd} problem in layer 2 to the incubation of the task in layer 1) and people switch between tasks. If people remember their work at example times t_1 and t_2, it is unclear what they will report: They might report the starting intimation on a layer 3 problem, the preparation they are doing for a layer 2 problem, or even reflect on the incubation in one of the other problems at time t_1.

In fig. 3.3 I suggest a model where the architects' task is divided into several *sequential models*. With this model I contribute to knowledge by filling a gap in the literature between the creativity models discussed in Cognitive Sciences and practitioners models of Design Thinking. For the discussion in this thesis, I am using Wallas's (1926) model simply because it is probably best known. Any other sequential model mentioned in section 2.7.4 would work just as well. In this abstract representation, the problem on layer 1 could be the task given to the architects in the brief of the tutorial. For the groups of the 2017 tutorial, the task was to develop the area around Derry's Cross in Plymouth. Conceptually, the development of a coherent master plan could be the overarching problem. This would include the position and development of individual sites and their relationship. The programme of a specific site could be seen as a level 2 problem and architects talked about it concerning process optimisation in a printing house or the requirements of a music school. Tasks on the third layer would address issues regarding material selection for walls or the placement of staircases. This idea has some interesting implications. In this case, the problem on layer 1 starts with the brief and gets verified with the grading of the project by the tutors. In many cases, the group prepares for this problem by reading about the history of the place, visiting the site, and discussing potential ideas in the group. At the same time t_1, they might start working on ideas for their sites. Results from these projects might feed back into the discussion of the master plan or not. Conceptually this means the top layer task remains in the preparation phase or advances to the incubation. At some point, for example during the group discussion at time t_2, the idea of a shared theme slowly develops and finally bursts into existence. This development would be reflected in the intimation and illumination phases. During all this time, the students might have improved their project to different stages; some might still be preparing, others might have a verified and working idea they need to paste into the master plan. Through the production of individual projects and the feedback from tutors, the main idea on layer 1 then gets verified.

This abstract example demonstrates that the specific sequential models form organisational and temporal relationships. In the following section, I introduce several possibilities for their conceptual organisation in the *multi-layered model.*

3.6 A multi-layered model of creative problem-solving

In this section, I am going to speculate on a few configurations of how two *sequential models* can relate to each other. For simplicity, I am only discussing the relationship of two processes at a time and further assume, that each person solely focuses on one thought at a time. This assumption is only for demonstration purposes; in theory, it is a simple process to extrapolate from the relationship of two models to adding a third, fourth, or fifth. Similarly, expanding the model to any number of parallel processes leads to similar models.

Even though the problems in the first case are not on different layers, the *sequence* is part of the multi-layered model to explain the succession of two tasks on the same layer. *Unrelated parallel* and *inspiration* can either be situated within the same layer or different layers, and *subtasks* are necessarily on different layers.

3.6.1 Sequence

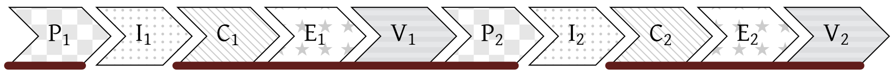


Figure 3.4: Two creative problem-solving processes in a sequence, each with a [P]reparation, [I]ncubation, Intimation ([C]ue), Illumination ([E]ureka), and [V]erification phase. The focus of attention (red line) is attending to something else during the incubation phases, as defined in the original model by Wallas (1926).

In the easiest case, the two problems are solved strictly one after another: people first solve a problem by going through all the five stages. Once the solution to problem 1 is verified, they start solving the next question by preparing it. There is no temporal overlap between the two problems, but they are both within the observed time frame. If the problem solver is asked before the beginning of the first preparation and again after the end of the second verification, then both problems are solved within this same period in *sequence*.

The knowledge transfer between the two problems only works in one way: all knowledge gathered within the first task is also available in the second task. Potentially the solution verified at the end of $_1$ could even generate problem 2. There is no transfer of knowledge possible from task 2 to task 1.

The architects I interviewed referred to sequential processes regularly. For example, while working on a subtask (see section 3.6.4), Joshua keeps trying different approaches in a sequence (appendix 1.1 line 59). At the beginning of a project, Ewan draws everything out that comes to his mind, one problem after another (appendix 1.2 line 11). Similarly, Alex draws one sketch after another to solve a problem, progressively advancing (appendix 1.3 line 55). Kiera calls it 'evolving', but means the same repeated process (appendix 1.4 line 121). Using the metaphors of bubbles for tasks he finishes off, Lewis is popping one after another (appendix 1.5 line 162). To address a problem, Bailey creates many different temporary solutions, one after the other, but potentially using different media (appendix 1.6 line 76). For the development of his music school idea, Charles solved one problem after the other in a sequence, starting with the acoustic qualities, then adding visuals to it, and finally a temporal and experiential component (appendix 1.7 line 220). Peter creates artefacts and then leaves them. After some time he then picks them up again and continues to work on that sequence (appendix 1.9 line 124).

Sequences, as hypothesised by the multi-layered model, are reported in the interviews. Students refer to them in different meanings such as iterative evolutions, incubation-like breaks between tasks, or just as a description of getting things done quickly.

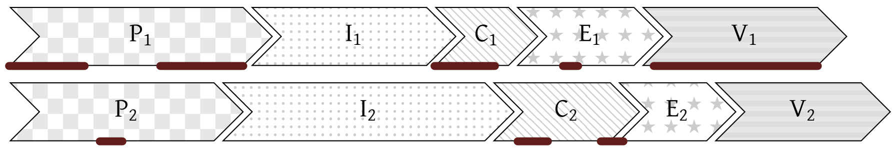


Figure 3.5: Two creative problem-solving processes happening at the same time. The red line marks the times when people consciously attend to one of the processes: [P]reparation, [I]ncubation, Intimation ([C]ue), Illumination ([E]ureka), [V]erification

3.6.2 Unrelated parallel

In another case, people start working on a problem at some point, and before they finish with a verification phase, they also start working on another problem. This second problem might or might not be finished earlier. If these two problems do not directly interact, then the creative problem-solving process is happening in parallel or *pseudo-parallel*.

In the interviews, the architects repeatedly referred to these type of processes. When Ewan is on what he calls a plateau, during which he only progresses little, he is working on several media in parallel. These processes seem to not influence each other, but one of them will eventually help Ewan to reach a solution. Within each medium he is also working in sequences (appendix 1.2 line 107). When Alex is stuck, he sometimes experiences what he calls 'back to nothing'. It seems to suggest that he has no idea where he is heading to, but just trying different things in parallel, and then one of the ideas might work out of pure coincidence (appendix 1.3 line 24). He also talks about the idea of 'juggling' as working on many unrelated problems at the same time (appendix 1.3 line 34). Kiera uses unrelated parallel processes to 'clear [her] head' (appendix 1.4 line 18). By thinking about his process of creating, Lewis seems to work on a meta-level at the same time, yet he does not report that this will directly influence his current problem (appendix 1.5 line 40). He also considers himself a 'Mad-Hatter' regarding his process, and by this he means that he is jumping between different processes he is working on in parallel (appendix 1.5 line 95). When Amelia talks about jumping between tracing historical Plymouth and working on her own site, it is, at least at the time of the interview, unclear how these tasks are related (appendix 1.10 line 96). Similarly, Spencer was talking about taking unrelated bits and pieces from different problems (appendix 1.11 line 86). Since the projects were not finished when I interviewed them, these seemingly unrelated processes might become subtasks in the future, when they inspire an overarching problem.

As demonstrated in the extracts, the interviewees refer to these pseudo-parallel tasks regularly. Interestingly, some students are using several parallel tasks to achieve a goal, while for others, these situations just seem to happen. In any case, the theorised pseudo-parallel processes from the multi-layered model can be observed in human creative processes.

3.6.3 Inspiration

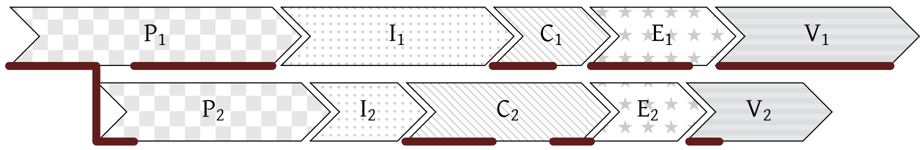


Figure 3.6: Two creative problem-solving processes happening within the same time period, the second being inspired by something during the preparation phase of the first problem but without any further interaction. The red horizontal line marks the times when people consciously attend to one of the processes, the vertical line represents transfer of knowledge between the tasks.

Another possible case is when working on one task inspires another one. This inspiration can happen during any phase of the initial task, and the inspiration might be perceived differently for each origin of the inspiration. As long as there is no knowledge or information consciously transferred back to the initial task, all of these different instances of inspiration are considered to be similar. The interaction between two potential tasks of which one inspires the other is depicted in Figure 3.6.

For Joshua, the work at the architecture school itself branches out and inspires real-world projects (appendix 1.1 line 35). When engaging with a landscape architect, this encouraged Alex to solve problems on his current project (appendix 1.3 line 78). Kiera explicitly mentions that she gets inspired by 'something' to work on a new problem until this project is over without feeding back any knowledge (appendix 1.4 line 10). During lectures, but not necessarily based on their content, Charles gets sometimes inspired for one of his projects (appendix 1.7 line 102). This then develops an idea in its own right. When Zak talks about his last year's project, he explains that initially the tutor would inspire him to do a task (appendix 1.8 line 11). After it 'clicked' with him, he would then be able to define his own sequence in a next step. The material or medium in which a problem is addressed helps inspiring new processes for Peter (appendix 1.9 line 176). Interestingly, the inspiration seems to work over long time difference as well when Peter gets inspired by problems from his sketchbook finished long ago (appendix 1.9 line 184).

The majority of inspirations seem to happen involuntarily. Depending on the perspective and the priorisation of each of the tasks, the same process is not only 'inspiring' in regards for the novel problem, but also 'distracting' from the initial one. In a broader sense, Peter voices that concern saying that finding something new to work with is good and bad at the same time (appendix 1.9 line 196). While the frustrating effect of being distracted is easily comprehensible, the positive effect of focussing on another task is known in Psychology as 'incubation' and discussed in more detail in section 2.5.5. While the underlying effects are still not well explored, a theory for this positive contribution is merely speculation, and phases similar to 'incubation' are missing or reduced in other frameworks such as design thinking and Cognitive Innovation, this aspect of involuntary switching and the effect of inspiration on the initial and secondary task seems interesting, but a detailed discussion is outside the focus of this thesis. Notably, these inspirations (and distractions), as hypothesised in the multi-layered model, were observed in the interviews with architects.

3.6.4 Subtasks

If some of the knowledge required to solve a task is not available to the potential problem solver, it can be generated by solving a second problem, a sub-task. Once this second task is solved, the result can be used in the first task. This integration of knowledge generated in the second task is the distinction between the cases mentioned in section 3.6.3.

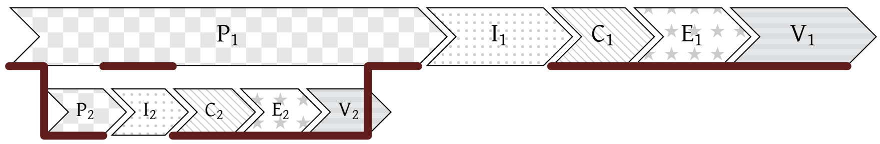


Figure 3.7: Two creative problem-solving processes happening within the same time period. The second one is inspired by something during the preparation phase of the first problem, and the solution to this second problem helps continue preparing for the first problem. In this case, task 2 can be seen as a subtask of task 1. The red horizontal line marks the times when people consciously attend to one of the processes, vertical lines represent transfer of knowledge between the tasks.

The sub-task can theoretically branch and merge again at different times in the creative process. In fig. 3.7 a gap in knowledge is discovered through the preparation for a problem. A sub-task solves the problem and transfers the knowledge back to the initial task. Now, this process continues. In fig. 3.8 the verified result from task 2 instead triggers a *Eureka experience* for task 1.

Examples in which the solution of the subtask solves early stages of the umbrella task include Ewan, who gives individual users of his site agency to understand the space. Their interactions then collate into group behaviour, and this group behaviour feeds back in his understanding of a problem (appendix 1.2 line 71). From drawing, Alex goes to use something else. This then changes the drawing, 'it's bound to be different' afterwards (appendix 1.3 line 50). Because drawing is such a quick process for Kiera, it is helping with an umbrella task to 'put it down' (appendix 1.4 line 110).

Lewis uses sub-processes a bit more long-term: with a looming deadline he gives himself a week to work on a subtask and uses the result produced in this time to advance his original project (appendix 1.5 line 180). When talking about the initial phase of the tutorial, Charles takes into account the contribution of individual sites to the master plan (appendix 1.7 line 47). Peter talks explicitly about the scale of models when referring to subtasks that solve problems on a different scale for him (appendix 1.9 line 323).

Other interviewees report how the result of a subtask helps them to solve the overarching task. Here Joshua accounts for an example where knowledge from a previously started task contributes to his current work (appendix 1.1 line 56). Kiera uses a sequence of quick subprocesses to solve an overarching problem (appendix 1.4 line 121). Bailey uses the technique of 'breaking down' into subtasks to identify problems and uses the results to solve the original problem (appendix 1.6 line 24). During the development of the project, Charles recalls to have worked on a building, created a model from it and suddenly, through this task, he had an idea how to solve a problem on the master plan. This is how his group came up with the idea of walled gardens (appendix 1.7 line 73).

For the case in which the subtask is part of the overarching preparation phase, potentially any number of subtasks can contribute to the main task. Kiera's quick sketches might serve as an example here. Even if the results are discarded at a later stage of the preparation phase or generate yet another sub-task, they contribute to the main problem. In the case when subtasks are contributing to the verification of a higher-level task, the number is also virtually unlimited, similarly to the subtasks contributing to the preparation of a problem. In contrast, there is only one sub-task possibly triggering or contributing to the illumination phase of the main task. Here the outcome of the subtask results in the sudden understanding of the umbrella task. For example, once Charles had the idea for the master plan, other subprocesses could not contribute to this problem anymore because it was, at least temporarily, solved.

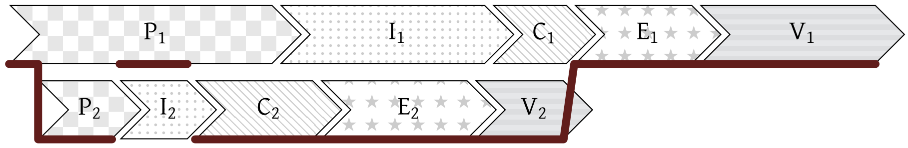


Figure 3.8: Two creative problem-solving processes happening within the same time period. The second one is inspired by something during the preparation phase of the first problem. The solution of this second problem triggers the illumination phase of the first problem. In this case, task 2 is a subtask of task 1. The red horizontal line marks the times when people consciously attend to one of the processes, vertical lines represent transfer of knowledge between the tasks.

3.6.5 Model comparison

The emergent model Sawyer (2016) developed maps very intuitively onto the *design process*. This might even be biased by the language used by the artists, who often learn about the *design process* during their education. Here I have shown that the same emergent model fits just as well on the *sequential model* of creativity, taking into account that the observed time contains more than one creative solution. I called this the multi-layered model.

For the data collected by Sawyer (2016), it might not make a difference which model to choose. On the other hand, in the data I collected during the interview with architects, they frequently mention *originality* and even *insight* as part of their process. This is difficult to integrate into the cyclic *design thinking model* as presented by Sawyer (2016). Instead, taking into account a sequence of several *sequential models*, the data from both artists and architects can be explained.

Based on the idea of several sequential models contributing to one overarching problem, I theorised that four different types of links between processes must exist. In the previous sections, I demonstrated that these links were experienced by the interviewees. Consequently, the multi-layered model introduced in section 3.5.2 fits the data from the interviews with architects. This wider generalisability of the multi-layered model of creative problem solving makes it a better model for the analysed datasets.

3.7 Conclusion

In this chapter, I report a study involving creative practitioners, who were interviewed about their creative process. I analysed the recorded data in accordance with a previous study by Sawyer (2016), who interviewed creative practitioners from a different profession. Results from the nine Art students he interviewed showed a great overlap with the data extracted from the interviews I conducted with eleven architects. This leads to the following three scenarios: 1. The emergent categories are quite common and are part of all conversations of a certain duration, at least within the two studied professional domains. 2. The questions that emerged from my conversations with the architects were, without knowing, similar to the questions that Keith Sawyer had prepared in advance. 3. There are some similarities between the process *How Artists Create* and how architects solve problems in their domain.

If the same categories emerge from all conversations, this would render Sawyer's (2016) and my analysis useless. To verify this would require a different analysis, such as qualitative content analysis, further interviews, for example with other professions, or additional measures. For the second point, it is unlikely that my questions and Keith Sawyer's are comparable since my interviews were unstructured. Hence the questions were inconsistent even between interviewee in my study because each conversation took a different course. There is no evidence to reject the third point. Therefore I assume for this chapter, that the creative process of artists and architects are similar, at least for the observed sample.

It is interesting to note that the *body of work* as the only one of the categories from Sawyer's (2016) emergent model explicitly refer to the creative product. While *Material* hints to the contributing artefacts, the other categories seem to be associated with the action of creating. Consequently, the creative practitioners seem more concerned with the creative process than with the produced outcome.

Between the interview of artists and architects, two notable differences in the results stood out. Firstly, the architects mentioned *originality* as a positive contributor to the process and, secondly, they reported experiencing *insights*. This contrasts with the two conclusions Sawyer (2016) drew, specifically that 1. the creative process of artists cannot be understood as a *sequential model*, but only in terms of the iterative *design process*, and that 2. insight is not part of the creative process.

To resolve the first inconsistency, I described a mapping between the *emergent model* by Sawyer (2016) and the *sequential model*. This also resolved the second inconsistency, as *insight* is part of the illumination phase in the *sequential model*. Furthermore, and based on the resulting observation that more than one creative process was part of the time observed through the interviews, I speculated on the relationship between several sequential processes within a general *multi-layered model*.

The *multi-layered model* provides a better explanation for the data observed in interviews with the architecture students and is neutral regarding the data from Sawyer (2016). The theoretical interactions between several sequential processes could still benefit from future observations and verifications.

When analysing complex phenomena, such as the Eureka moment, using a mixed-methods approach is likely to uncover more information about the phenomenon than using just one method. After discussing the qualitative data of the architects' interviews, in the next chapter I will introduce a method I designed to collect quantitative data on the creative process. Within the project, the initial set of interviews with architects were conducted early in 2015. Anecdotes from the interviews with architects influenced the design of the paradigm described in the following chapter. Specifically, the choice of mixed media such as using image and text in the same task, and the idea that the solution itself is of minor importance, are taken from these observations. Once the data from the task 'Dira' was collected, I went back to another cohort of architecture students to strengthen my initial observations, but also to see if what I learned from the experiment holds within the realm of creative practitioners.

4 Dira as a platform to understand Eureka moments

To observe the moment solutions emerge as part of the creative process and test correlates of and interventions on this process, an experimental paradigm is required. From the literature review on the operationalisation of insight in section 2.4, I conclude that there is no direct measure of *insight*. Instead, related phenomena are used to identify these moments, such as positive affect, sudden restructuring, confidence about the solution, processing fluency, or neural correlates to any of these effects. Further, the tasks currently used to study *Eureka moments* rely on these related phenomena. Even though a link between observed phenomenon and 'Eureka experience' is well established, the chronology or even causality remains unclear. For example, take the connection between mood change and insight: Does *insight* increase mood (Chermahini & Hommel, 2012), does a stimulated positive mood cause *Aha moments* (Isen, Daubman, & Nowicki, 1987; Ritter & Ferguson, 2017), or are they both results of another process? On the conceptual side, the moment solutions emerge are part of the creative *process* or the *action*, yet the assessment through tasks typically relies on the *product* or *artifact* (Glăveanu, 2013; Rhodes, 1961). Consequently, I identify a need to detect emerging solutions directly and not via proxy phenomena.

Based on the theoretical discussion of *insight* in section 2.4.1, the critique of existing tasks in section 2.5, and what I learned from the interviews with architects in section 3.7, I designed a new laboratory-based task. I called this novel experimental paradigm the *Dira* experiment (Loesche et al., 2018). With this experiment I contribute to the knowledge of measuring the creative *action*, specifically by narrowing down the moments of emerging solutions. Participants of *Dira* are asked to find a non-obvious, unusual, and remote association between a given text and one of six images. In a computer-based setup, all of these on-screen elements appear blurred by default and can only be seen clearly when the mouse hovers above them (see fig. 4.1). Tracing the mouse movement and the hover time on each image allows to measure the time participants spend attending to an image during task execution. After selecting their solution, participants are asked to report their subjective experience. The experiment consists of forty of these individual *Dira* tasks. I hypothesise that the combination of behavioural and self-reported measures can be used to identify a distinctive behaviour when solutions emerge. I further hypothesise that people can report the intensity or strength of an emerging solution in more nuances than a binary scale.

4.1 Rationale

In this section, I describe the origin of *Dira* and how I acquired the problems that I asked participants to solve.

4.1.1 Development of *Dira*

Dira has been developed out of the necessity to collect fine-grained measurements of the creative process. As an experimental paradigm to observe the moment when solutions emerge, *Dira* needs to address one fundamental requirement: the solution should not be known to the prospective problem solver from the beginning. Here, a solution is either the answer itself or an algorithm how to arrive at the answer. If either was known at the moment the task was given, *Dira* would merely provide measures related to other processes, for example processing fluency and memory retrieval. This addresses one potential problem of existing word-based tasks discussed in section 2.5.2, where language fluency potentially influences the results. Furthermore, the memory aspect attends to an issue discussed in the context of insightful tasks in section 2.5.3, where previous knowledge related to the solution is often not controlled for.

In each *Dira* task I ask people to find a connection between a short text and one of six images. I assume that, if the text does not describe a feature of the images but instead has a non-obvious association with aspects of at least one image, then people cannot know the answer from the beginning. Instead, they might arrive at the solution either through controlled processes in creative cognition (Beaty & Silvia, 2012; Silvia et al., 2013), or unconscious associations (Kenett, Anaki, & Faust, 2014; Mednick, 1962). In the first case, participants generate several metaphors or potential solutions from available information and select one of them as the best fit at a specific time. In the second case, existing associations are mediated through similarities of common elements before one of them is identified as the best match. In both cases, the solution emerges at a distinct moment before participants choose an image as the solution.

For the developed task I assume that two different modalities for the stimuli are advantageous to isolate remote conceptual associations. If the two stimuli that were to be matched used the same modality, matches could be found for different aspects. For example, matches between two visual stimuli could not only be based on the depicted content, but also on colours, forms, and dynamics of the image. For two verbal stimuli the constructing syllables, cultural connotations, and language fluency of the problem solver would play a decisive role in the selection of an answer. By asking people to match content from different modalities, I hope to circumvent the issues above. The experience of an emerging solution relies on the inherent quality of the task; in the case of *Dira*, on the text as well as on each of the potentially associated images.

Dira was inspired by the tabletop game *Dixit*. During each round of this card game, combinations of text and images are generated. Based on a given image, one player generates a short story, and all the other players select one of their unique cards to match the story. The scoring system assures some difficulty by penalising descriptive texts and easy to find associations, as well as associations too remote to be identified by other players. More experienced *Dixit* players reportedly develop a skill to generate imaginative stories that have a non-obvious connection to a given image and they also select non-obviously associated images for a given story. Consequently, the generated combination of text and images theoretically conforms with the criteria for our conceived task, and the quality of the association potentially increases with the players' experience.

Dixit, a commercially available and highly acclaimed game, is played all around the world. The 84 unique images of a *Dixit* card deck are described as 'artwork' [1] and 'dreamlike' [2], and have previously been used in teaching a foreign language (Cimermanová, 2014) and in research on imaginative design narratives (Berger & Pain, 2017). The cards have also inspired interventions to foster creativity (Liapis, Hoover, Yannakakis, Alexopoulos, & Dimaraki, 2015), and are suggested as 'an additional source of inspiration' (Wetzel, Rodden, & Benford, 2017, page 206) for an ideation methodology.

Usually *Dixit* is played locally around a table, however Boite-a-jeux[3] provides an online gaming platform to play it across distances and with other players of a similar skill level. In August 2014 I accessed the publicly available recorded game data of 115,213 rounds of *Dixit*. I filtered this initial dataset for English rounds with six players. After stopword removal (such as 'the', 'is', 'at') and word stemming, I removed the rounds with stories containing the most frequent words from the 90th percentile. Looking at the story and images, candidates for the *Dira* task were selected from the remaining 1000 rounds of recorded *Dixit* games. With the help of another experienced *Dixit* player, I skimmed through these candidates; based on observations during a pilot study – carried out at the University of Plymouth with 13 volunteers – I selected 40 sets.

To control for participants domain-specific knowledge, I assigned categories to each story. I created the categories using a similar coding technique as in identifying emergent categories for the architects' interviews in section 3.2, with the text of the *story* representing a *meaning unit*. The

[1] Dixit publisher's website http://en.libellud.com/games/dixit, last access: 2018-02-23
[2] Wikipedia: Dixit (card game) https://en.wikipedia.org/w/index.php?title=Dixit_(card_game)&oldid=823435686, last access: 2018-04-05
[3] http://boiteajeux.net; Last access 2017-11-15

following list shows the eight categories that emerged from this coding, with the number of attached stories in parenthesis: Literature (8), music (6), film (7), science (7), popular culture (12), and high culture (7) as well as word games (11), and literal interpretations of visual cues (10). The number of attached stories amounts to more than forty, since each story could belong to more than one knowledge domain. For example, the sentence "Standing on the shoulders of giants" is meaningful for people in the scientific community exposed to the life and work of Newton, but also for fans of the Britpop group 'Oasis', who released an album with the same name. Hence this story would be linked to *science* as well as *music* and *popular culture*.

The name *Dira* for the experiment is a play on the name of the game *Dixit* the task was inspired by. *Dixit* is the Latin for 'he or she said' (Wiktionary, 2018b) and was supposedly used by the French publisher to highlight the story-telling aspect of the game. *Dira* is French for 'he or she will point out' (Wiktionary, 2018a) and highlights the cultural origin of the game as well the intention to predict the participants' selection.

The order of the tasks within *Dira* was initially chosen at random, but kept the same throughout all experiment reported in this chapter. Verbal protocols were considered to trace the processing within the task. With my primary interest in the process, the discussion in section 2.5.6 suggested talk-aloud protocols as too invasive and were diregarded. Based on the discussion in section 2.5.7, mouse-tracking was chosen as the process-tracing method for the *Dira* task. This also has an pragmatic aspect, since it allows running several studies in parallel and without expensive hardware setup. Furthermore, and in addition to the controlled laboratory study, this task has the advantage to be replicable, since it could potentially be used in the future for internet-based studies with larger numbers of participants.

4.2 Method

4.2.1 Experimental design and procedure

The computer-based experiment *Dira* is programmed as a series of different screens. From the participants' perspective, *Dira* combines perceived freedom to explore the on-screen elements with aesthetically pleasant stimuli. Using a familiar mouse based interface, the order and duration of interaction with the text and images are up to the prospective problem solvers. The images are taken from the *Dixit* card game which has been praised for its artistic and beautiful drawings. Moreover, the whole experiment is designed like a game. As discussed in section 2.5.5, these design choices are intended to make the *Dira* tasks "inherently interesting or enjoyable", one of the critical elements that are known to increase intrinsic motivation (Ryan & Deci, 2000, page 55). In turn, Baas et al. (2008), da Costa, Páez, Sánchez, Garaigordobil, and Gondim (2015) have shown positive correlations between intrinsic motivation and performance in creative problem solving tasks.

A *Dira* experiment starts with an opening sequence consisting of a *welcome* screen, a *questionnaire*, and a *description* of the task. This initial series is followed by 40 *rounds* containing a *fixation cross*, *quiz*, *rating*, and optional *explanation* or *elaboration* screens. The experiment concludes with an on-screen *debrief*.

The opening: Welcome, Questionnaire, and Description screen

A *welcome* screen explains the basic idea of the study as well as potential risks and the right to withdraw data. The study only continues if participants understand and agree to the minimum requirements that have been cleared by the Faculty of Health and Human Sciences Ethics Committee at the University of Plymouth. Once participants have given their consent, they are shown the *questionnaire*.

Figure 4.1: Example of the screen how participants might have seen it during a *quiz* (left), all elements unblurred (centre), and the colour coded positions (right). The centre and right subfigure show an example mouse movement. The mouse positions at at onset and offset times t_1 to t_7 are recorded as raw data. The figure on the right shows assigned symbolic names and colours for each position 'a'–'f' and 'story' as used in later plots. The story was initially inspired by the image with the white circle, because in 'image c' the shadow reveals the true intention of the figures in the foreground. The black circle marks an example of a 'chosen solution'. Dixit images by Libellud [4].

During the *questionnaire*, participants are asked to specify their age, gender and primary language, and if they have participated in the study *Dira* before. They are also asked to rate their fluency in understanding written English and familiarity with the card game *Dixit* on seven-point Likert items. Participants are also asked to rate themselves in 14 additional seven-point Likert items, four of which belong to the Subjective Happiness Scale (SHS) developed by Lyubomirsky and Lepper (1999) and ten more of the Curiosity and Exploration Inventory II (CEI-II) as published by Kashdan et al. (2009). The scales were chosen because emotional states, openness to experience, and intrinsic motivation are known to influence problem solving (Baas et al., 2008; Beaty, Nusbaum, & Silvia, 2014; Eccles & Wigfield, 2002).

Once participants have completed the questionnaire, the procedure of the experiment is explained to them in detail in a *description* screen. This screen also holds a minimal and neo-Gestalt-inspired definition of the 'Eureka moment' as "the common human experience of suddenly understanding a previously incomprehensible problem or concept", for accessibility reasons taken from Wikipedia (2016). Afterwards, the 40 *rounds* of the experiment begin.

The round: Fixation cross, Quiz, Rating, and other screens

Each *round* starts with a *fixation cross* which is shown at the centre of the screen for a randomised time between 750 ms and 1,250 ms. Afterwards text and images appear on the *quiz* screen as illustrated in fig. 4.1: one text on top and six images in a grid of two rows by three columns. Unless the participants hover the mouse on top of these elements, the letters of the text are shown in a randomised order, and the images are strongly blurred. An example can be seen in the second screen of fig. 4.2, which shows the text "Don't judge a book by its cover" with the letters in a randomised order and images blurred except for *image f*, over which the mouse pointer hovers. The recording of hover times during the *quiz* allows to track when participants pay attention to each of the elements and for how long (Navalpakkam & Churchill, 2012). For a further description of the blurring technique in context of mouse tracing, refer to section 2.5.7. On this screen, participants attempt to find the image that they think is most likely associated with the text and select it through a single click. Following the contemplations in section 2.5.5, there is no time limit for completing this task. Once participants have chosen a solution, they are advanced to the *rating* screen.

During the *rating* screen, participants are asked to rate their performance in the *quiz*. They are asked the following four questions, with the range of possible responses on seven-point Likert items in brackets: "How confident are you that the solution is right?" (not confident — very confident), "How hard was it for you to come up with the solution?" (not hard — very hard), "How strong did you experience a Eureka moment?" (not at all — very strong), and "How happy are you with your answer?" (very unhappy — very happy). After submitting the answers, the next *round* starts with a *fixation cross*. The next section 4.2.2 describes the additional screens that were added to the *round*, depending on the experiment.

Debrief

Participants who have completed the 40 *rounds* conclude their participation with the *debrief* screen. Here they are informed that the study intended to measure the timing of their behaviour during the *quiz*. Participants are encouraged to give additional feedback concerning the experiment, and they have the option to leave an email address in case they want to be informed of the results of the study. This on-screen debrief was followed by a short unstructured personal discussion relating to their experience in the Dira experiment.

4.2.2 Experiments

Dira was administered in three different between-subject experiments. In experiment 1 the participants were not given any feedback regarding their answers and they had no reference to evaluate their performance. In experiment 2 participants were presented with a potential solution at the end of each round, to see how this help would affect their behaviour and experience. In experiment 3, participants were asked to elaborate on their solution; this was done with the aim of increasing participants' engagement with the task. Experiment 1 was the first to be run, and all participants at the time followed the same protocol. Subsequent participants were randomly assigned to either experiment 2 or experiment 3.

In experiment 2 I added the screen *explanation* to each *round* as illustrated in fig. 4.2. Appended after the *rating*, it is the last screen before the start of the next *round*. The *explanation* screen shows the *intended solution*, the image that initially inspired the storyteller to invent the text. I also showed participants a short explanation on how the *intended solution* and text are connected. The short sentence is based on a text taken from the stimulus dataset and is designed to help the participants: One method to solve a *Dira* task is to empathise with the storyteller and find the *intended*

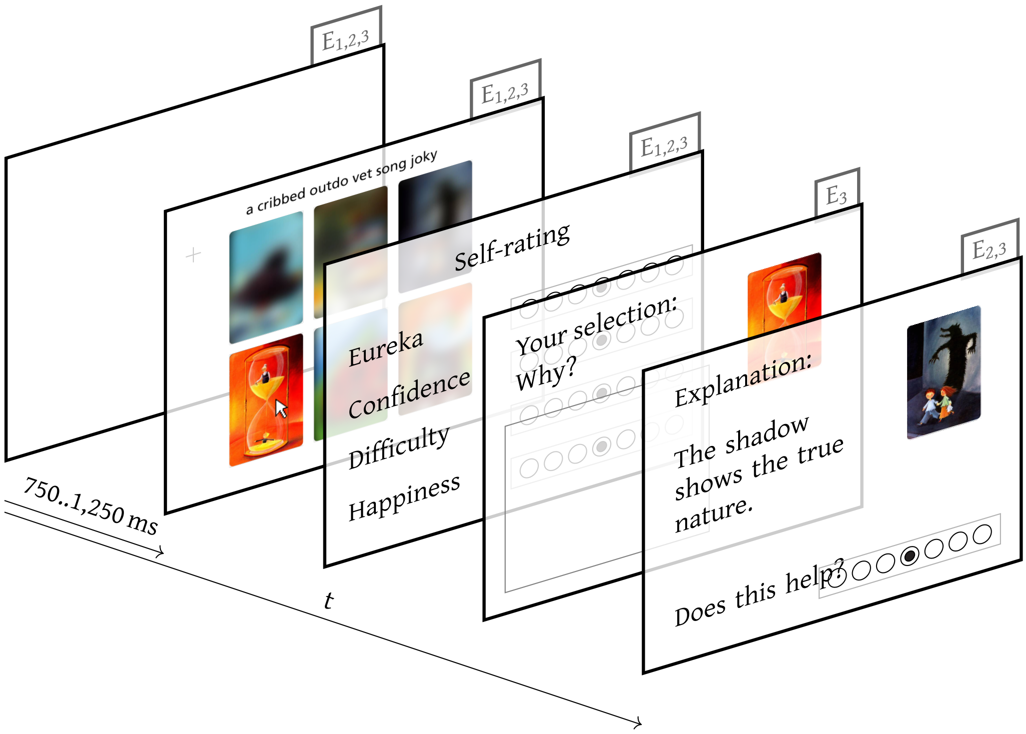


Figure 4.2: Experiment of the *Dira rounds*. Each parallelogram represents a part of the experiment; the annotation in the upper right corner identifies in which experiment the parts appear. Dixit images by Libellud.

solution that initially inspired the text. To assess the success of this help, the participants were then asked to rate "How much does the Explanation help [you] to understand the association between image and text?". Their answer ranged from 'not at all' to 'very much' on a seven-point Likert item. Submitting the answer started the next *round* of experiment 2 with a *fixation cross*.

In experiment 3 an *elaboration* screen was placed between the *rating* and the *explanation* screen, as shown in fig. 4.2. In this screen, participants saw the given story and their selected image, and they were asked to elaborate on their decision. Afterwards, they saw the *explanation* screen described above. Once they completed these additional screens, participants restarted the next *round* of experiment 3 with a *fixation cross*.

4.2.3 Task administration

The controlled study *Dira* is designed as a computer-based task administered in a laboratory setup. The task was administered through a custom developed web application delivered through a full-screen web browser. The hardware setup of an optical mouse and 22 inch LCD screen with 1,920×1,080 pixel resolution was familiar to the participants from the library and public computing spaces across campus. The experiment was delivered in a dedicated room with a maximum of five participants at the same time, who were asked to stay silent during the experiment. I conducted the individual brief and debrief outside the room to keep any distraction to a minimum, and collected informed consent for participantion from participants; then they were accommodated to a computer showing a *welcome* screen.

4.2.4 Participants

124 participants between the age of 18 and 56 ($\overline{age} = 22.6$, $sd = 6.99$) were recruited from a local pool of pre-registered psychology students and members of the public. Psychology students received course credits and points for running their studies. Members of the public, mostly students

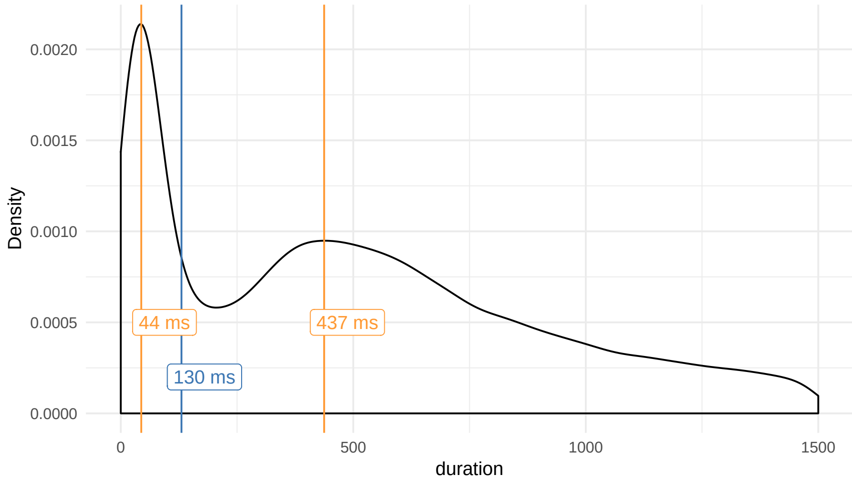


Figure 4.3: Distribution of interaction times on elements during the *quiz*. The modes of the bimodal distribution are marked with red lines. The cutoff time between the two distributions, a result of the classification described in the text, is shown in blue.

from other courses, received monetary compensation around National Minimum Wage per hour. The overall sample is therefore similar to the one described by Henrich, Heine, and Norenzayan (2010). Participants were randomly assigned to one of three different *Dira* experiments.

4.2.5 Data pre-processing

The data collected during the *quiz* of the *Dira* task are intended to trace the participants' thought process through their behaviour. Since their thoughts are influenced by or reactions to what they see on the screen during the experiment, I discuss here what they can actually perceive. The recorded dataset includes chronological information concerning the order in which participants engage with elements, as well as the duration of the interactions. This data requires a more detailed look.

A rather simple observation stems from the chronology or order in which participants engage with elements. This shows that people do not hover over the text element in all rounds. Participants who have not seen the text will not be able to find an association between the text and images for that round. One of the reasons for not looking at all images, on the other hand, could be that the solution was already found. Therefore, rounds with missing interactions for some of the images were still analysed, while rounds in which participants did not look at the text were excluded from further analysis.

The order in which participants look at the images does not influence their understanding of the task. All of the six images have a connection to the text and it is previously unknown which of the images will be selected by any of the participants as their solution. Furthermore the most frequently chosen images are at different locations, initially chosen at random. Moreover, there is no intended or know connection between the images that would influence the knowledge acquired through the order of interaction. This is different for the text and images, as both of these elements have a different role in the *quiz*. There is only one text per *round* that needs to be matched to one of the six images. The order in which the text is looked at plays therefore an important role. Images that people have seen before looking at the text play a different role than the images seen afterwards. When looking at the text, the content of the images seen before needs to be recovered from memory to extract the meaning related to the new information. This might require revisiting these images for additional details. When looking at the same image before and after the text, it is unclear what type of information is perceived during which interaction. Therefore rounds with image interactions before the first text interactions might differ from the other rounds, while the order in which participants look at images does not have an influence on the processes of interest.

The number of interactions and the length, on the other hand, can have an influence as discussed below and in the rest of the chapter. In general, the duration of interactions with text and images is assumed to relate to the amount of acquired and processed information. The duration is driven by individual differences as well as differences between tasks. This includes processing fluency as well as ease of information retrieval, but also fatique over time, and task difficulty. These effects can be classified either as between subjects or between rounds. In the analysis, for example in section 4.3.2, they are modelled with game round and participants as random effects. However, the data also includes quick movements that reveals elements potentially for a shorter amount of time than required to perceive its content. Specifically, previous research does not provide evidence for perceptual discrimination between visual stimuli shown for less than 100 ms (VanRullen & Thorpe, 2001; Zoefel & VanRullen, 2017). Furthermore, Salti et al. (2015) argue for a required exposure of more than 250 ms necessary to consciously perceive a stimulus.

Theoretically, if people in the *Dira* task want to look at an element not adjacent to the current mouse position, they need to move the pointer across one or more elements. In this case, the distance of the mouse pointer from the target image is between 1.5 times and 4.3 times the size of the target. According to Fitts' law, the task of moving to a distant image has an index of difficulty between 1.3 and 2.4. Applying the extreme values for throughput suggested in Soukoreff and MacKenzie (2004), participants are estimated to require between 260 ms and 640 ms for the whole distance and therefore between 150 ms and 170 ms to cross an image between the starting position and the target image. During this movement, the element is briefly unblurred on screen. fig. 4.4 shows examples of this movement at the beginning of rounds 4 to 7.

For the data collected during the *Dira* experiment, the density of the duration of interactions in fig. 4.3 shows how often participants interact with elements for certain durations. The bimodal distribution suggests that there are at least two different types of behaviour recorded. Shorter interactions, in fig. 4.3 marked as the local maxima around 44 ms, are distinctly different from longer hover times peaking around 437 ms. A cluster model fitted to the log-transformed duration using two components (Scrucca, Fop, Murphy, & Raftery, 2016) classifies 17,849 interactions as short and 63,452 as long, divided at 130 ms.

The predicted movement time according to Fitts' law and the identified time dividing the bimodal distribution of hover times suggest that the shorter engagements with elements might be movements across the element, targeting another one. If participants follow the mouse movement and see the intermediately unblurred image on screen during the shorter engagement, the following unblurred target image acts as a backward mask. Incidentally, the measured time could be related to the predicted time applying Fitts' law to the *Dira* task. In any case, assuming that specific information from a higher conceptual level is required to identify remote associations in the *Dira* task, these activations would require more time than the previously mentioned 100 ms (VanRullen & Thorpe, 2001; Zoefel & VanRullen, 2017), assumptions that are in line with the single neuron recordings done by Quiroga, Mukamel, Isham, Malach, and Fried (2008).

For the *Dira* experiment I am interested in interactions for which participants can distinguish between the content of the different images. Concluding the different cited streams of research I assume that shorter interactions below 130 ms from the bimodal distribution shown in fig. 4.3 have no or little influence on the process *Dira* intends to capture. Instead, the threshold for consciously perceiving the content of images is presumably much higher. In accordance with Fitts' law, I assume that the shorter observed behaviour represents mouse movements across elements moving for a different target without cognitive processing of the image. Consequently, element interactions below the identified 130 ms are excluded from further analysis.

4.3 Results

In this section, I first report on the type of raw behavioural data collected during the *quiz* and derived measures such as the chronology of information acquisition. I then report results from the self-reported items during the *rating*. I then show that the number of interactions with elements relates to the reported strength of the Eureka experience. Finally, I report results of the length of different interactions in comparison to the reported strength of reported Eureka experience.

4.3.1 Available process-tracing measures

Participants' interaction with elements on the *quiz* screen is a metric for tracing their problem solving process. While the current chapter focuses on the moment solutions emerge, the experimental paradigm could also be used to trace other aspects of the creative process. Since the extracted behavioural measures are vital for understanding the subsequent writing, I elaborate on the raw data and its derived measures in this section.

To illustrate the kind of data collected in *Dira*, I will now discuss fig. 4.4 in more detail. The duration of interaction with each element is the difference between offset and onset time which is the raw data recorded during the task. fig. 4.4 shows the example of one participant's interaction within the first 10 seconds of each of the 40 *rounds*. Each of the coloured bars represents a timespan during which the mouse pointer hovers on top of an element. The length represents the duration, and the colour signifies with which element the participants interact. For example, in the first round on the bottom of fig. 4.4, this particular participant spent a long time on *image b* (for colour and naming scheme see fig. 4.1). The second round instead starts with three short interactions with *image d*, *image e*, and *image b* followed by a short time without any element interaction before hovering on top of the *text* for almost two seconds. Some rounds, like the third one, are finished within the ten second period shown in fig. 4.4, others like the first two continued for a more extended period.

Figure 4.4 also shows additional data that is available in *Dira*. I refer to the moment participants select their solution as the *quiz time* since it ends the current *quiz*. The example participant selects the solution for round 3 at around 8,500 ms and round 4 at around 8,000 ms. The selected solution, for example, *image c* for round 3, is also indicated as a horizontal black line for the *rounds* in fig. 4.4. The vertical black line marks the end of what I call the *First Full Scan*, the end of the interaction with the seventh unique element. Participants have interacted with each element at least once at the end of the *First Full Scan*. The number next to the vertical axis in fig. 4.4 represents the strength of the Eureka moment participants indicate during the *rating* screen. The example participant reported no Eureka experience

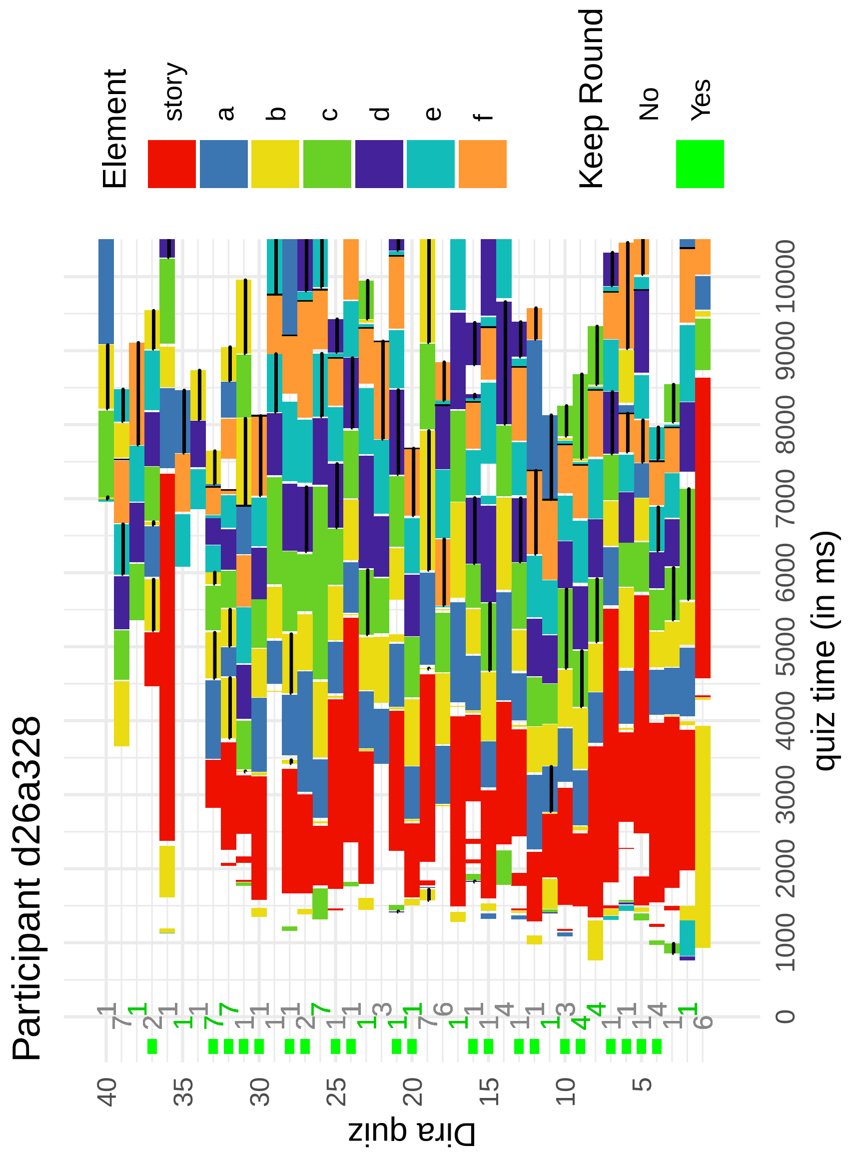


Figure 4.4: One participant's interaction with text and images during the first 10 seconds (x-axis) of each of the 40 rounds (y-axis). The length of each coloured bar notifies the duration, the colour identifies the position of the element. Horizontal black lines mark the items that are selected in this round, the vertical black lines mark the end of the *First Full Scan*. The numbers between one and seven next to the y-axis show the reported strength of the Eureka experience for that round, in green if the chosen solution is the one that inspired the text. The green blocks mark rounds that are kept for further analysis. For details see text.

for rounds 2 and 3, but a strong one for rounds 19 and 26. If the number is shown in green, the selected solution is the same as the *intended solution* that initially inspired the story. Finally, the green box next to the vertical axis indicates rounds that are part of the analysis and not filtered out for one of the reasons explicated previously in section 4.2.5. For example, only rounds in which people initially look at the text are used in the analysis. As discussed in section 4.2.5, this allows a direct comparison of interaction times and duration. Quick movement data is removed first which means that round 4 is kept for the analysis since the two quick interactions before the text hover time are considered to be too short to allow people to perceive their content. On the other hand, the hover time on 'image a' before the text interaction in round 2 is long enough for the participant to see the content. After seeing the text and then going back to this image, the processes might differ from rounds in which participants do not see an image first. The order in which participants look at the images do not influence if they are kept or not. In summary, only rounds in which people look at the text first are kept for the analysis for reasons of having comparable data.

4.3.2 Interaction times with elements

During the *quiz*, two different types of stimuli are present on the screen, namely text and images. In the analysis of *Dira*, the interaction time with elements is an important measure of information acquision. Consequently, it is interesting to see whether the interaction times between the two modalities are fundamentally different. Besides, the image and story potentially play a different role in the task: the story in the quiz might be perceived as the question or task, while each of the six images represent potential solutions that link to the only story.

A plot of the average interaction times with the image versus the text addresses this question by revealing how they are related. In fig. 4.5 each point represents one *quiz*, one axis shows the interaction time on the image, the other is the story interaction time. Rounds in which participants spend a longer time at the images but a shorter time on the story will show up in

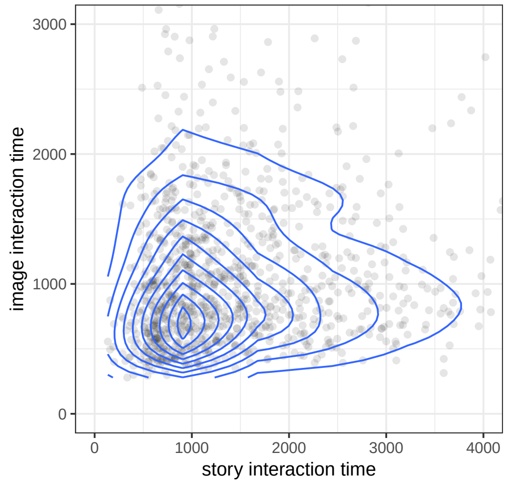


Figure 4.5: Density of average interaction times on images over story.

the upper left area of the plot, rounds with shorter interaciton times on the images but longer interaction times on the text in the bottom right area. Slower rounds are closer to the upper right area, while faster rounds are closer to the bottom left area. The density estimation of the distribution highlights the relationship between interaction time with the images and the story and allows an estimation of the behaviour of participants in the majority of *Dira* rounds.

In fig. 4.5 the estimation for the highest density of rounds is around 900 ms story interaction time and between 700 ms and 900 ms image interaction time. This pattern towards longer story interaction time as compared to the image interaction time is consistent across all rounds. This suggests that participants spend longer times on the story than on the images, and that potentially two different cognitive processes are at work.

Within the *Dira* task, the longer interaction time on the story might have two different reasons. Either the modality of the element requires participants to spend a longer time on the text to perceive its content, or the task of connecting the story with one of the images results in a longer interaction. In the latter case the perception of the stimulus itself plays a

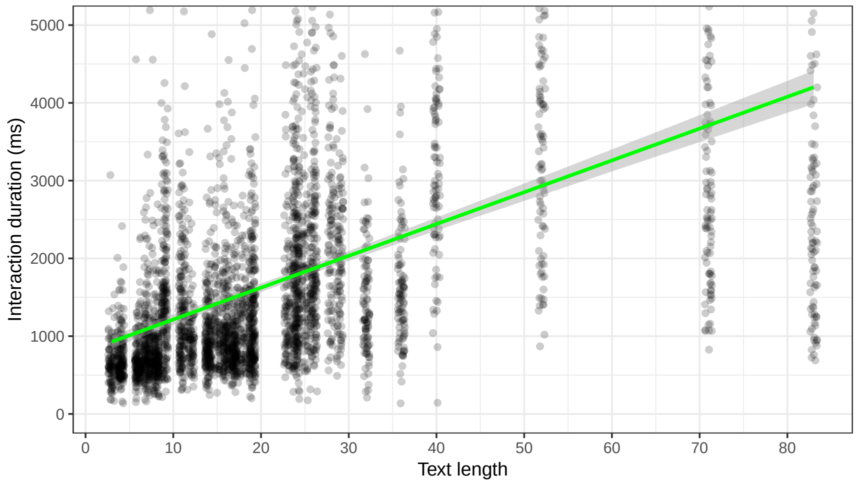


Figure 4.6: Interaction duration with the text as a function of text length. Each dot represents the text interaction time for one *Dira round*. The green line represents a fitted linear model, showing a longer interaction time for longer texts.

minor role, resulting in similar interaction times for different text stimuli. On the other hand, if the modality of the stimulus and therefore the perception itself plays a role, then the interaction time would relate to some intrinsic quality of the element. For example, a longer text would increase the reading time, or a syntactically more complex story would require a longer time to comprehend.

Here I test the following assumption: If the previously observed longer interaction time on text (as compared to image interactions) is caused by the role of the text in the *Dira task*, then the interaction time would not significantly increase with longer texts. On the other hand, if the perception time is caused bottom-up by text itself, then an increase of text length would also increase the interaction time.

In fig. 4.6 the interaction time is shown as a function of the text length (mean(story length) $= 20.8$, SD(story) $= 16.88$. The figure suggests that longer texts result in longer interactions. A fitted linear mixed-effects model with game round and participant as random effects shows that text length affects interaction duration ($\chi^2(1) = 32.0, p < .01$), increasing it by $39.8ms$ per letter. This suggests that the difference between the interaction time for images and text is not primarily caused by their role in the *Dira task*, but instead by the content of the text.

4.3.3 Available self-reported measures

Participants of the *Dira* task are required to provide self-reported measures in addition to the implicit behavioural data collected during the *quiz*. During the *reporting* screen they are asked to account for the strength of their just encountered Eureka experience, their confidence in the given solution, the perceived difficulty of the task, and their current happiness on seven-point Likert items respectively. Besides, participants in experiments 2 and 3 are also asked to rate how well they understand the link between the text and a preselected solution, the inspiring *intended solution*. In experiment 3 they are furthermore asked to write down how their solution is associated with the text. These measures are collected during each of the 40 *rounds*.

Other tasks previously used in the literature rely on self-rating of the *insight* experience as well, but people are usually forced to answer on a dichotomous scale (Danek et al., 2014b; Jarman, 2014; Kounios et al., 2008; Laukkonen & Tangen, 2017; Ovington, Saliba, Moran, Goldring, & MacDonald, 2015). In *Dira*, and following the work by Bowden and Jung-Beeman (2007), Danek et al. (2014a), MacGregor and Cunningham (2008) mentioned in section 2.4.2, I give participants the possibility to report their subjective experiece on a broader scale to substantiate the discussion in section 2.4.2 empirically. Confidence was one of the feature repeatedly found in the literature on *insight* (Hedne et al., 2016; Topolinski & Reber, 2010a; Webb et al., 2016). Furthermore, the *Dira* task has an *intended solution* which initially inspired the story, but all other images are linked to the story as well. Therefore *Dira* does not have a single 'objectively' correct answer, but following the argument of Hedne et al. (2016), confidence can act as a proxy-measure of the subjective feeling of correctness. Difficulty is

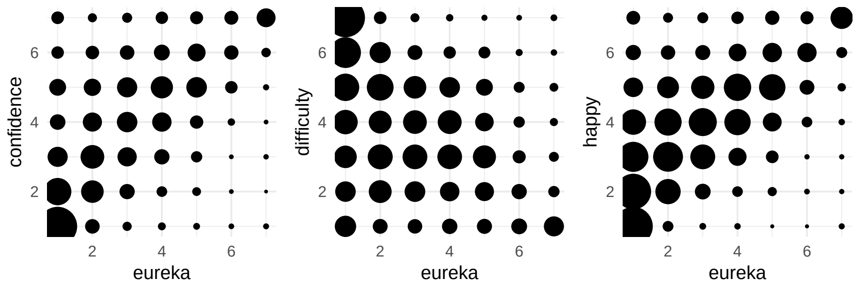


Figure 4.7: Confidence, perceived task difficulty, and happiness related to the reported strength of the Eureka experience. The size of the circle represents the number of rounds in which the combination was reported, larger circles representing more answers.

assessed as a measure to compare the different *Dira* rounds. Finally I assess the happiness of the participants since positive mood and mood changes have been found to be associated with *insight* (Baas et al., 2008). Also, Abdel-Khalek (2006) previously demonstrated that single-item measurements of happiness are sufficient to assess positive affects and emotions.

As illustrated in fig. 4.7, for rounds in which participants report a strong Eureka experience they are also confident regarding their solution. Rounds with weaker or no Eureka experience are reported across the whole spectrum of confidence, but with a tendency towards low confidence as well. Instead, rounds with strong Eureka experiences are rarely rated as low confidence. This asymmetry leads to an overall Spearman's rank correlation of $\rho = .62, p < .01$. In contrast, rounds with strong reported Eurekas rank low in difficulty and rarely as 'hard to come up with a solution'. Rounds with a low or no Eureka experience are perceived with varying difficulty. The overall correlation between the reported Eureka experience and stated task difficulty is $\rho = -.41, p < .01$. Finally, for weak or no perceived Eureka, participants express a range of different happiness, but only high happiness for strong Eureka experiences. Reported

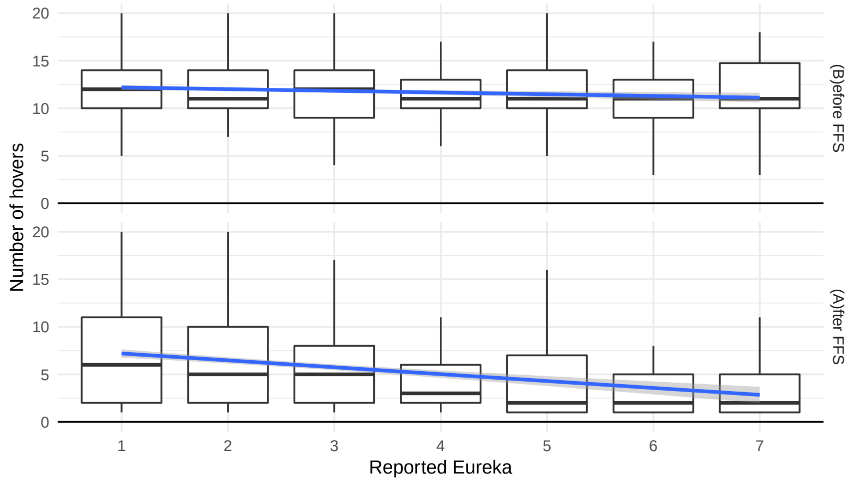


Figure 4.8: Number of interactions before (top row) and after (bottom row) *First Full Scan* over the reported strength of Eureka experience.

Eureka and happiness are correlated by $\rho = .6, p < .01$. The reliability of the rating is either good for reported Eureka ($\alpha = .86$) and difficulty ($\alpha = .87$), or acceptable for happiness ($\alpha = .78$) and confidence ($\alpha = .77$) based on Cronbach's alpha. Conceptually these four measures are linked in section 2.4.2, particularly through the literature review of Topolinski and Reber (2010a), who discuss the relationship between ease, positive affect, and confidence to *insight*. This link is reflected by the data collected in *Dira* with good reliability, as suggested by Cronbach's $\alpha = .86$ across the four measures. Consequently, these findings confirm my second hypothesis that participants can report their experience on more than a binary scale.

4.3.4 Number of interactions

In this section, I take a first look at the relationship between the self-reported intensity of the Eureka experience and the chronology extracted from the behavioural data. For example, when participants acquire information during the *quiz* and they find a solution, they might stop looking at more images. Therefore I hypothesise that the Eureka experience is stronger for rounds with fewer interactions. Figure 4.8 shows how many elements a participant interacts with during each of the 40 rounds of the *Dira* experiment. The sub-figure on the top shows the number of interactions during the *First Full Scan* before participants have seen each element at least once. An average of ten to twelve interactions means that participants tend to go back and forth between elements even before they have seen all seven elements. More specifically, if participants look at elements in a certain order, looking back at one element and then continuing with the round can result in two additional interactions. To give an example: one participant has looked at *image a* and *image b* and then goes back to *image a* before continuing with *image b*, *image c*, and *image d*. In this case, the participant had interacted twice with *image a* and *image b* during the *First Full Scan*. This particular round would have accounted for at least nine interactions before the end of the *First Full Scan*. To arrive at the numbers shown in fig. 4.8, this seems to happen twice in a typical *First Full Scan*.

To test the above hypothesis, I built an ordinal mixed-effects model (Christensen, 2015) with reported Eureka as a dependent variable. The number of interactions, the classification into before and after *First Full Scan*, and the experiments were used as predictors. The rounds of the experiment as well as participants were considered as random effects. Results from this model indicate that there is a significant negative effect (estimate $= -.06, z = -6.27, p < .01$) of numbers of hovers on the reported Eureka before the end of the *First Full Scan*. The model also shows a significant negative effect (estimate $= -.35, z = -3.68, p < .01$) for the number of interactions after the end of the *First Full Scan*. This confirms my hypothesis that the Eureka experience is stronger for rounds with fewer interactions during and after the *First Full Scan*. On the other hand, there is no evidence that experiment 2 or 3 have an effect compared to participants in experiment 1 (estimates $= [-.12, -.28], z = [-.35, -.88], p = [.73, .38] \not< .01$).

During the *First Full Scan*, the above model shows a significant effect of the number of interactions with elements on the strength of the Eureka experience. Across all experiment, this difference is between 12.61 interactions for no or low Eureka experiences and 11.38 interactions for strong reported Eurekas. After the *First Full Scan* participants do not interact with all the images and text, again. The significant effect of the number of interactions on the reported strength of Eureka is higher this time and more pronounced in fig. 4.8: the difference is between 9.65 interactions for no experience of a Eureka and 4.24 interactions for a strong one. There is no evidence for an effect of the experiment on these results. Considering that the behaviour of participants with different Eureka experiences seems to change before the end of the *First Full Scan*, it is interesting to examine the behaviour during the *First Full Scan* in more detail. Hereafter I will examine whether the duration of hovering over elements provides additional information.

4.3.5 Last hover during First Full Scan

Here I report the results for the hover duration on the seventh unique element. It is the last image during the *First Full Scan* and the first time participants interact with this specific element. Following up on the previous finding of an interesting difference between interactions during and after the *First Full Scan*, I want to narrow down the time of emerging solutions by exploring this specific hover time. More specifically I show the ratio of the duration on the last image compared to the mean of previous interactions. The chronometrical measure of hover time is illustrated in fig. 4.9. To correct for individual differences in processing speed, I plot the ratio of the hover time on the last image and the average hover times on all other images during the *First Full Scan*. By plotting the ratio instead of the absolute values, the 'baseline speed' of participants is ignored, for instance if a person is quick or slow in the actual round. fig. 4.9 shows separately the ratio of rounds in which this element is the one (C)hosen later in the experiment and rounds which end on a (N)on-chosen one.

Figure 4.9 shows two effects: Firstly, for the *First Full Scans* ending on a chosen image, the median of the hover time is roughly 50 % higher on that element than for non-chosen ones (1,323 ms vs 855.9 ms). Secondly, less time seems to be spent on the last non-chosen image than on the previous

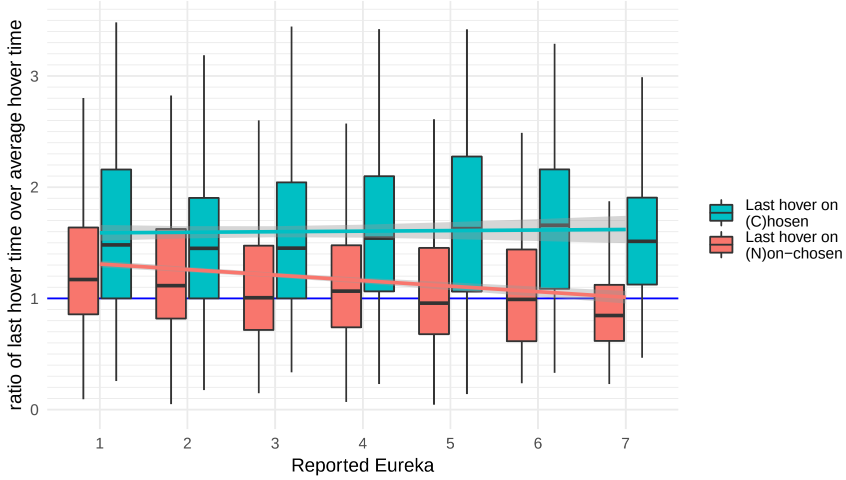


Figure 4.9: The ratio between the last hover time within the First Full Scan and the average of all other hover times in the *First Full Scan*, separated by rounds in which participants hover over the chosen image last vs the ones in which they look at another picture. A value of one means that they are equal, lower than one means the last scan is shorter than the previous ones. In addition to the box-plot (showing the median and distribution), the lines show a linear model fitted to the mean ratio and surrounded by the 95 % confidence interval in light grey.

ones for stronger Eureka experiences, whereas more time is spent on the last image for low Eureka values. To quantify these effects I built an ordinal mixed-effect regression model with the strength of the reported Eureka experience as a dependent variable and the ratio between last and average hover time, the type of element for the last hover, and the experiment as predictors. The round of the experiment and the participant were used as random effects. This model shows a significant effect of the ratio on the strength of the reported Eureka (estimate $= -.24, z = -6.1, p < .01$) as well as for rounds in which the last element is the chosen one. This model shows a significant effect of the ratio on the strength of the reported Eureka (estimate $= .2, z = 2.71, p < .01$). There is no evidence for the ratio in experiment 2 or 3 affecting the reported Eureka intensity (estimate $= [-.09, -.55], z = [-.32, -.32], p = [.75, .05] \nless .01$).

The negative slope of the ratio over the strength of Eureka, in fig. 4.9 particularly evident for the last hover on the non-chosen image, suggests that a solution has emerged before the end of the *First Full Scan*. The change of the ratio is either the result of a decrease of the numerator, an increase of the denominator, or a combination of both. The numerator decreases if participants spent less time on the last image when having a stronger Eureka experience. The denominator represents the average time spent on all previous images. It increases if participants spend more time on at least one of the previous images. If participants had Eureka experiences while looking at the image they are going to choose later, and this would be associated with them looking longer at that image, this would increase the denominator in the rounds which end on the non-chosen images. The observed increase would also explain the difference between rounds that end on chosen and non-chosen images. If participants spent less time on subsequent images, for example after a Eureka experience, this would decrease the numerator for the rounds ending on non-chosen images, but not for the ones ending on chosen images. This interpretation of the observations suggests that the measured ratio is a compound of chronological effects and hover duration. Therefore I focus now on the duration spent on the chosen image and its relation to the strength of Eureka.

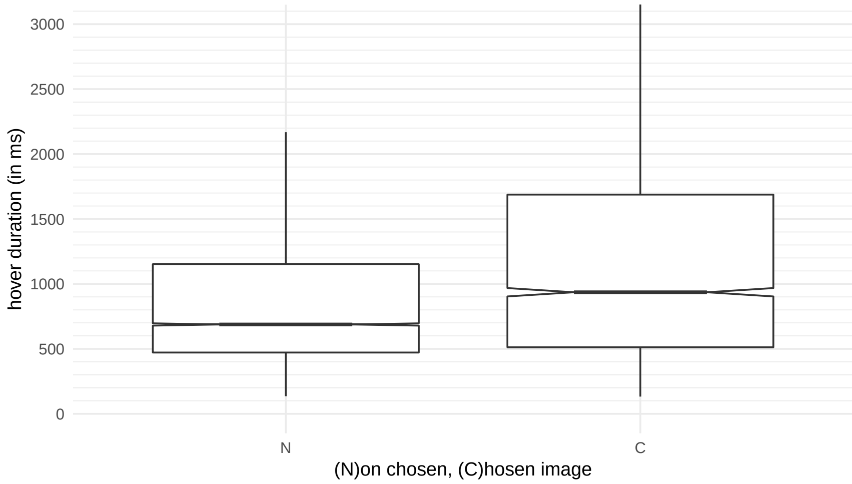


Figure 4.10: The hover duration on the images after participants have seen the story and within the *First Full Scan*, without movement data. The time spent on the (C)hosen picture is longer the time spent on the five other images that are (N)ot chosen.

4.3.6 Chosen images and length of interactions

The observation of the ratio of last and average interaction times during the *First Full Scan* suggests that the interaction times between chosen and non-chosen images differ. Instead of a compound measure, I purely show the duration of hover times during the *First Full Scan* on (C)hosen and (N)on-chosen images in fig. 4.10. A Mann-Whitney test indicates that the duration of viewing chosen images (duration $= 935.9$ ms) is significantly longer than for non-chosen pictures (duration $= 687.8$ ms), $U = 20,873,370$, $p < .01$). Furthermore, there is a significant difference between the three experiments regarding the hover duration on non-chosen images ($H = 42.07$, $p < .01$, $Md_{\text{Experiment 1}} = 663.2$, $Md_{\text{Experiment 2}} = 679.7$, $Md_{\text{Experiment 3}} = 727.9$), according to a Kruskal-Wallis test. At the same time, I did not find support for a difference between experiments for the chosen images ($H = 9.18$, $p = .01 \not< .01$, $Md_{\text{Experiment 1}} = 879.8$, $Md_{\text{Experiment 2}} = 915.9$, $Md_{\text{Experiment 3}} = 1,048$).

I now look at the link between hover duration and reported Eureka experience in more detail. I built an ordinal regression model with the reported strength of the Eureka experience as the dependent variable. Using the hovering time on the chosen images as a predictor, there was no evidence for a link between the strength of Eureka and interaction time (estimate $= .01, z = .21, p = .83 \nless .01$). This is not unexpected, since the raw data includes slower and faster participants. Instead, if an ordinal mixed-effects model considers the participant as a random effect, there is statistical evidence supporting the link between hover duration and Eureka experience (estimate $= .14, z = 3.16, p < .01$). From this example, I conclude that the raw recorded hover durations with text and images have little validity in connection with the self-reported measures collected during the *rating* screen. To address this, I remove the influence of participants and the task by considering the ratio between the time spent on chosen and non-chosen images calculated separately for each round. This suggested ratio between interaction times for a single round and with a single participant does not include chronological components related to the order of interactions; it is between measured times only.

Figure 4.11 shows the ratio between the hover duration on the chosen image and the average time spent on the other images. This ratio is higher for rounds in which participants report a stronger Eureka experience. An ordinal mixed-effects model fitted to the data supports this observation. The model uses the strength of the reported Eureka experience as a dependent variable and the ratio between the time spent on the selected image compared to the average duration on all other images as well as the experiment as a predictor. The round of the *Dira* task and the participant are used as random variables. This model confirms that an increase in the ratio corresponds to a stronger Eureka experience (estimate $= .02, z = 5.65, p < .01$). With a ratio of 1.3 for no Eureka and 2 for a strong Eureka, participants seem to spend approximately 50 % more time on the chosen image in rounds when they report a strong Eureka experience. However, the model does not provide evidence for an influence of experiment 2 or 3 on the reported Eureka (estimates $= [-.1, -.58], z = [-.33, -2], p = [.74, .05] \nless .01$).

Here I have presented two main findings. Firstly, the observations of the

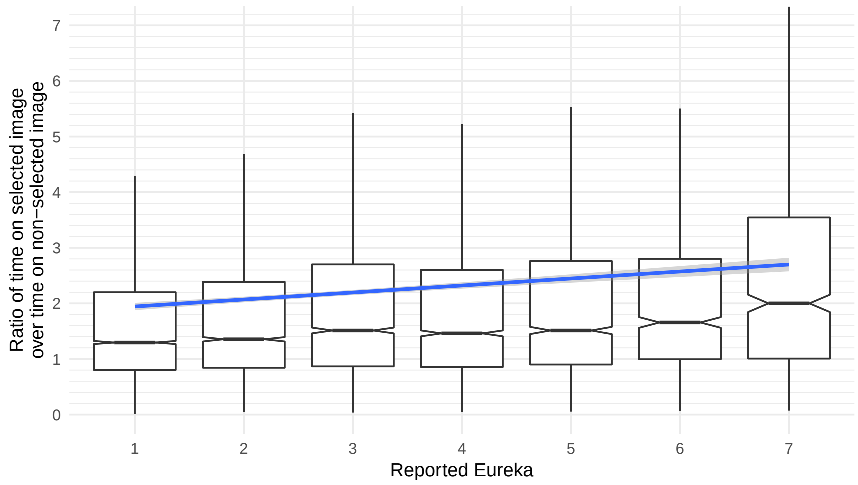


Figure 4.11: The ratio of time spent on the chosen image over non-chosen images as a box-whisker plot with a linear model fit to the mean. The median for the ratio depicted in the box-whisker plot shows that participants spend nearly 1.3 times as much time on the chosen image compared to the others for a low Eureka, but about twice the time for a strong Eureka.

length of interaction with elements show that participants spend more time on the images they will select later in the task. Secondly, for rounds with a strong reported Eureka experience, the time spent on the chosen image is significantly longer than in rounds with a weaker or no Eureka experience.

4.4 Discussion

The moment when a solution to a problem emerges is an extraordinary experience. It causes people to cry out *Eureka*, *Aha*, or *Uh-oh* as vocalisation of their changed mood as discussed in section 2.2.1 and section 2.2.3 respectively. In this chapter, I suggest *Dira* as a novel experimental paradigm to observe these moments as part of the creative process. In section 2.4 I have discussed how previous studies rely on the judgement of creative artefacts, actors, affordances, and audiences — or use proxy phenomena to assess the process contributing to creativity, innovation, and problem solving. In this study, I tested 124 people who participated in a controlled lab experiment designed to study the emergence of solutions. Using the novel experimental paradigm *Dira*, I recorded behavioural data during several creative processes. Specifically, I determine the chronology and chronometric measures of participants' interaction with the stimulus text and images as potential solutions. After each *round*, I ask the participants to self-report their experience on four different items. Addressing the gap in existing measures of the creative *action*, I contribute to knowledge by having developed a novel experimental paradigm. Here I discuss the implications of combined behavioural and metacognitive measures in the *Dira* task.

4.4.1 Eureka experiences in *Dira*

Results from the behavioural data within the *First Full Scan* of *Dira* show that participants spend longer times on images they are going to select as their solution. Moreover, the length of the interaction on these chosen images is linked to the strength of the reported Eureka experience, with longer hover durations associated with stronger Eureka experiences. As shown in section 4.3.5, the median interaction time on the chosen image is about 50 % longer than on the non-chosen ones. Another result related to the strength of Eureka is reported in section 4.3.6. For rounds that evoke a strong Eureka experience, participants spend about 50 % more time hovering on the chosen image as compared to rounds with no or low reported Eurekas. The current analysis does not allow drawing any conclusions regarding causality, since the study was observational. Future studies could test if more extended engagement yields stronger Eureka experiences or if stronger Eureka experiences lead to longer hover durations.

After participants have interacted with the chosen image, they are less likely to continue looking for more elements according to the results in section 4.3.4. Supposedly participants continuously scan the elements on the screen for a solution. If they find an association, the number of elements they interact with afterwards is related to the strength of the Eureka experience reported later. The significant effect can be observed as early as during the *First Full Scan* and the initial interaction with the images. These results suggest that something distinctive might already be happening during the initial engagement with the images.

With support from the ordinal mixed-effects model considering behavioural and self-reported measures, I also confirm my first hypothesis that behaviour happening during the *quiz* influences the reported intensity of Eureka. It would seem natural that the Eureka experience also happens during this time. This timing does not comply with the classical sequential model, where the *insight* is preceded by preparation, incubation, and intimation and the verification phase is supposedly rather quick due to little constraints from the task itself. However, the multi-layered model explains this timing. In fig. 4.12 I conceptualised *Dira* as a *multi-layered model* with two layers. As suggested in section 4.4.2, each interaction with an element is considered to be part of the same problem on layer 2. In section 4.3.4 I have demonstrated that participants interact several times with the same element and hence they are shown as longer processes in fig. 4.12. In reality these processes would start at differnt times and most likely also end at different times. Within each process the length of a phase is varible. For demonstration purposes I shortened all phases on *image b* except *verification*. If *image b* was to become the selected solution, this moment early on in the experiment might be perceived with a *Eureka experience*. Already in this simplification, the participant might perceive two different *Eureka moments* either at t_1 for understanding the image and potentially making a connection to the text, or at t_2, after the participant has engaged with all images. While *sequential models* only explain the *illumination* at t_2, the *multi-layered model* has greater explanatory strength for early *insight*.

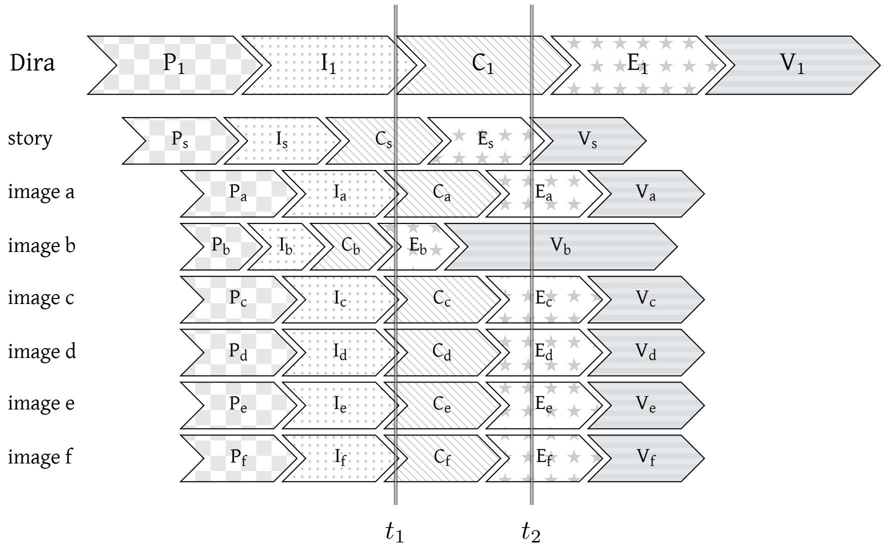


Figure 4.12: *Dira* represented as a multi-layered model on two hierarchies. Finding a connection between the story and one of the images is the top-layer, understanding and interpreting each each element are the sub-tasks. In *Dira* the first interaction with an image could be considered the start of its [p]reparation phase. The phases would have different length.

However, we cannot rule out the possibility that the Eureka experience is the result of a post-event evaluation. In any case, due to the short experimental time, these experiences would qualify as *immediate insights* according to Cranford and Moss (2012). In their study of convergent thinking they found a difference between solutions found through a *classical insight* sequence and *immediate insights*. The *immediate insights* only consisted of an *Aha* or*Eureka* experience and were considerably faster. This quick *insight* is also in line with the idea of intrapersonal creativity or *mini-c* introduced by (Beghetto & Kaufman, 2007). In future studies it might be worth exploring if these observations could be explained by a multi-layered model as well.

It would also be interesting to design a modified version of *Dira* to elicit *non-immediate insights* as well, for example by tapping into the thought suppression as used in the delayed incubation paradigm (Kenneth J. Gilhooly, Georgiou, Sirota, & Paphiti-Galeano, 2014) or more generally in *little-c* type of tasks. I leave this speculation for future studies.

4.4.2 Participants' interactions with *Dira*: A speculation

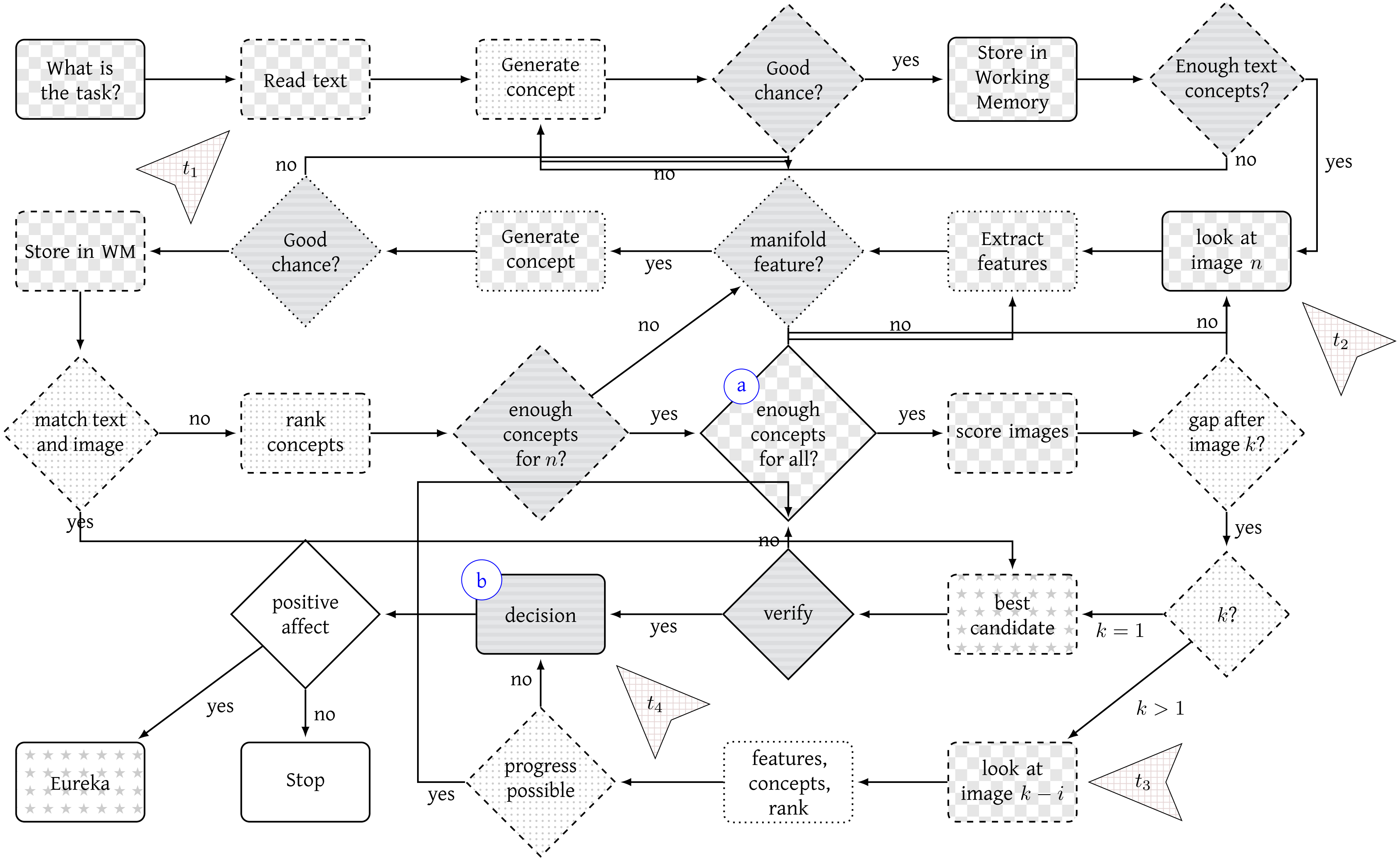


Figure 4.13: Schematic diagram of the process for solving one Dira task. The workflow starts in the top left corner with the question *What is the task?* and at some point just *Stops*, potentially with a *Eureka* moment (bottom left). The time t_1 is measured when the mouse hovers over the text, each time a participant looks at an image time t_2 is stored, the time t_3 is taken each time participants revisit an image to score images, and time t_4 when a decision is made. Under the assumption that participants generate enough concepts for each image at first sight, the change at a can be estimated. From the selection made at b, a measure of *correctness* could be assumed.

The interface of the *quiz* appears rather simple with only seven elements on the screen and the mouse as the only way to interact. On the other hand, the freedom to explore these elements in any order creates many possible interaction patterns. Participants could start with any of the images like *image d* or the text and then look at the other elements in any order they want. In section 4.2.5 I began to discuss some observed interaction patterns, for example not looking at the story at all. If I wanted to speculate on the cognitive processes involved in the *Dira* task, then each interaction with an element would consist of several subtasks. To further reduce complexity, I only discuss the *rounds* in which participants look at the story first.

In fig. 4.13 I give a speculative illustration of what participants might do to solve the *Dira* task, heavily inspired by information processing accounts. The participants' potential thought processes can be traced starting on the top left box asking "What is the task?" and follow the arrows. For example, the first step could be to read the text. This interaction with the *Dira* task is observed and recorded as time t_1. In this speculation, the prospective problem solver interprets the ambiguous story and generates a *concept*, an internal representation, for it. If the participant assumes this concept has a good chance of being correct, it is stored in memory. Otherwise, another concept is generated. If the memory contains enough good candidates, then the problem solver advances to the next element, image 1. A sequence of processes similar to the text is done for each image, starting with feature extraction. From this manifold feature, concepts are formed and stored in memory until the participant is satisfied with the extracted knowledge and advances to the next image. At the end of the *First Full Scan*, the participant has at least one concept for each image n. If the person now arrives at the decision marked with *a* and does not have enough concepts for all images, some of the images might be revisited. Possibly the generated image concepts are now ranked regarding their match with the text concept. Now, if there is a gap between the highest rank and the next ones, then this image is a good candidate, after verifying the match, might get selected at *b*. Depending on other features mentioned in section 2.4.3 like mood, suddenness, or ease of processing, the solution might be perceived as *insightful*. If the gap in the ranked image concepts is not after the first image, then further iterations of looking at images might be used to make the decision.

From the description and the many loops in fig. 4.13 it seems obvious to describe the problem-solving in *Dira* with iterative models such as design thinking. Nevertheless, I want to offer another alternative here. In fig. 4.13 some boxes are surrounded by a continuous line, others by dashed lines, and the third type by dotted lines. Let us assume, that these boxes belong to processes on layer 1, layer 2, and layer 3 of a multi-layered-model as introduced in section 3.7 respectively. Under this assumption, understanding an image would be considered a layer 2 problem, with the extraction of features as a sub-task. Understanding one image would at some point contribute to answering the overarching question "What is the task?".

In this schema, *Dira* only provides sparse data. Specifically, the times marked with t_1 to t_4 and the decisions at *a* and *b* are the behavioural data used in this analysis. Inferences about the behaviour between measures could only be drawn based on large amounts of data. Adding other instruments, for example, neuroimaging methods might help in identifying the timing of more of these elements. For the moment, and based on the data at hand, I suggest that only analysis on layer 1 and, to some extent, layer 2 is feasible. As an indirect and secondary implication from this current section, I suggest that the previously introduced *multi-layered model* helps in discussing creative processes such as the ones involved in the *Dira* experiment.

4.4.3 Subjective experience

In more detail, the strong *Eureka experience* in rounds with high confidence is consistent with previous findings introduced in section 2.4.3. The reported confidence is potentially linked to a subjective feeling of being correct.

Happiness and, more generally, a positive mood is strongly linked to *insights* and *Eureka experiences* in the existing literature as shown in section 2.4.3. In the *Dira* task participants experiencing a strong *Eureka* seldom report low happiness, but instead are consistently happier than with weaker or no *Eureka experiences*. The fine-grained exploration of the emotional space associated with emerging solutions could be a topic for future research.

The results for the relationship between difficulty and Eureka show that *Dira tasks* with a strong Eureka experience are rarely perceived as difficult. This finding seems counter-intuitive from the perspective of the classical *insight sequence* introduced in section 2.4.1 in which a complicated impasse has to be navigated. However, perceived difficulty can change in hindsight as discussed in section 2.4.3. Finally, yet another interpretation is that the participants experience *insights* in *Dira tasks* that are not difficult for them.

4.4.4 Differences between experiments and personalities

I administered *Dira* in three different experiments with a between-subject design. As explained in section 4.2.1, I asked participants questions from the Subjective Happiness Scale (SHS) and the Curiosity and Exploration Inventory II (CEI-II) during the opening sequence. The four items from SHS result in a single measure for "happiness from the respondent's own perspective" (Lyubomirsky & Lepper, 1999, page 150). The ten items from CEI-II represent two dimensions of curiosity, "the motivation to seek knowledge and new experiences" (stretching, here 'CEI_stretch') and "a general willingness to embrace the novel, uncertain, and unpredictable nature of everyday life" (embracing, here 'CEI_embrace') (Kashdan et al., 2009, page 995). For the observed sample I did not find supporting evidence for individual difference within the collected data. Specifically, fig. 4.14 shows that there is no significant correlation between reported *Eureka* and any of the metrics assessed to inform about the personality traits. There are low correlations between the happiness reported after each round and the SHS. This suggests that the single item measurement after each round is related to people's overall happiness. At the same time the low correlation highlights that other effects influence the self-reported happiness after each round, potentially the difference between rounds. The low but significant correlation between self-reported happiness and

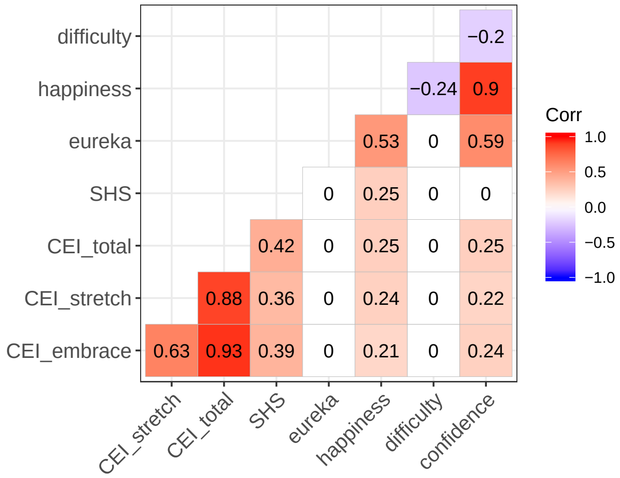


Figure 4.14: Correlation between subjective happiness (SHS), the motivation to seek new knowledge (CEI_stretch), the willingness to embrace novelty (CEI_embrace), and participants' self reports after each round aggregated on an individual level. Only significant correlations are shown, a value of '0' shows that the correlation does not pass the significance threshold of 0.05.

the CEI shows that both dimensions of curiosity and positive mood are correlated. Since the correlation is lower than between the CEI and SHS on a participants' aggregation level, this once again suggests that the experiments have an influence on the self-reported happiness. This requires further exploration, but suggests that the manipulations in 'Dira', as well as the measures regarding happiness could be meaningful. Out of the self-reported measures, only confidence shows significant correlations with personality traits related to CEI-II. From a conceptual level this suggests that people who are more curious are also more confident in their choice of solutions. While this requires further unpacking in future research, this is a promising trend. Reported *eureka* and *difficulty* not surpassing the signficiance threshold should not be overinterpreted, but could suggest that *Eureka* can be experienced independent of individuals subjective happiness and curiosity, and that the task difficulty is not related to personality traits measured with the two instruments.

Considering the difference between experiments, I observedsignificant results between some of them. For example, section 4.3.6 shows a longer hover time on the non-chosen images for experiments 2 and 3. Likewise in section 4.3.6, I find no evidence that the length of the interactions by itself predicts the strength of the Eureka experience. However, the duration acts as a predictor if I consider participants as a random factor in the model. With the current analytical method, the cause remains unclear, but results suggest that individual variability moderate the experience and performance in the *Dira* experiment. Future research could expand the findings of the current study to address how and if personality traits accurately predict the reported *eureka experiences*.

In a trial-by-trial comparison, I reveal a link between fewer interactions and stronger *Eureka experiences*. In section 4.3.4 I compare the differences in the number of interactions observed between Eureka intensities, separately during and after the *First Full Scan*. I observe a significantly larger variance between no and strong Eureka experiences after the *First Full Scan*. This difference implies that the experience is influenced by element interactions and not by the participants' approach to the task.

4.4.5 Experimental control

The participants' freedom to choose the order and duration of stimulus interaction is supposed to increase task engagement, but it does not come without costs. The flexibility to look at elements in any order allows participants in the *Dira* experiment to not look at elements necessary to solve the problem. For example, some participants choose not to look at the text before selecting one of the images. Furthermore, participants who start with the text and try to find a matching image afterwards might use a different approach to solve the problem than others who engage with images first and interact with the text later during the task. In the first case, they only need to store the text itself or a derived concept in working memory to match it against each of the images they look at. In the second case instead, they need to remember up to six images and related concepts to match each of them with the text. For the analysis in this chapter, I filtered for rounds in which participants started with the text and removed all others. Future studies could eliminate the second case through a changed experimental design by specifying the chronology, for example by showing the text first.

As discussed earlier, the bimodal distribution of hover durations suggests that participants unblur elements for at least two different reasons. As discussed in section 4.2.5, participants might either intend to move the mouse pointer across by targeting elements on the other side or consciously engage with the text and images. In the current study, I assumed interactions shorter than 130 ms to represent mouse movement across elements. While these interactions were removed post-hoc from the current study, avoiding short unblurring could be implemented in the experimental design. The elements could only be shown clearly if the hover time exceeds the movement time predicted by Fitts' law (Soukoreff & MacKenzie, 2004).

4.5 Concluding *Dira*

In the *Dira* task, I estimate the moment of the emerging solution based on the participants' behaviour and self-reports without relying on additional indicators. The data suggests that this is happening during the *First Full Scan* when people interact with the element they will select later on. Like in many design and engineering problems more than one solution is considered to be correct in this task. This is one of the results from chapter 3 that came out of the interviews with architects. For *Dira* I demonstrate how behavioural data and meta-cognitive monitoring are integrated by this instrument to identify sub-processes of the creative process.

The results suggest that participants can distinguish between *Eureka experiences* of different strengths. Thus, my results support the previous findings mentioned in section 2.4.2 that *Eureka experiences* are not limited to having or not having an *insight*, but that the perception of this experience can have different intensity levels. Future studies should keep this in mind when assessing *Eureka experiences*.

Looking at the whole process of finding a solution to a 'truly ill-defined problem' (see section 2.6.2), people show a distinctive behaviour early in the process related to the strength of their *Eureka experience*. While the exact timing remains unclear, observations through *Dira* help narrowing down *insight*. The reported results further suggest that *immediate insights* exist and can be reported by people who experience them.

The creative process is often studied indirectly through creative artefacts, actor, audience, or affordances. While this current work focuses on the temporal aspects of the *insight*, *Dira* could be utilised to observe other sub-processes of the creative action with no or little manipulations to the experimental paradigm. Notably the duration of observing the elements could help to understand the stage Wallas (1926) coined as 'preparation'. The time course of 'incubation' could be observed by adding a distractor task and tracing people's behaviour similarly to the *Dira* experiment. Finally, when taking into account the time participants spend on their chosen solution and their secondary potential solution, more process based information about the 'verification' phase could be collected. With advancements in these other potential applications of tasks similar to *Dira*, the creative action could be observed in more detail. Future studies could revisit the relationship between *insights* and creativity (Beaty, Nusbaum, & Silvia, 2014). Furthermore, creative actor's traits such as fluid intelligence (Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014) or working memory (Lee & Therriault, 2013), as well as the creative affordances of different task types could be observed. In section 2.5 I have discussed a range of potential problems, such as convergent thinking tasks, insightful problems, and divergent thinking tasksk, but also complex real-word problems could be considered. While these applications are currently merely speculations, I have shown in this work the use of *Dira* in advancing the knowledge about *insight*. Nevertheless, the current findings go beyond the isolated *Eureka moment* as they situate the phenomenon within the whole process of solving a 'truly ill-defined problem' in this novel experimental paradigm.

5 General Discussion

5.1 Introduction

Interviews with creative practitioners in chapter 3, the development of a novel process-based psychological experiment in chapter 4, and a cross-disciplinary literature review in chapter 2, constitute the main contributions of this thesis. These different methodologies allowed me to further the understanding of the moment when solutions emerge, often coined as *insight*, *Eureka experience*, or *Aha moment*. While the research topic is easy to convey in everyday language and the well known 20-second elevator pitch, the use of this imprecise wording in scientific papers on this topic had considerable influence on all three branches of this project.

A review of existing tasks as a precursor to developing *Dira* revealed that the phenomenon had been operationalised through different aspects: the phenomenon was so self-explanatory to previous authors, that they failed to provide a precise definition in their publications. When the observed phenomena were defined, then this was often done through a mixture of theoretical and experiential descriptions, as shown in section 2.4.3. The currently used terminology seems elusive but had apparently been so from the beginning. In section 2.2.2 I compared the original German version and the first English translation of one of the seminal works of the field (Köhler, 1921/1963, 1925/1976). From my analysis, it seems that the term *insight* was coined somewhat by accident in the translation, rather than intentionally by the author. As a consequence, this did not only generate distinct conceptual branches for the two languages I observed, but also the English term blended with previous technical uses and everyday language. This confusion is apparent in the attempted clarifications by the same author even more than 20 years later. The imprecision of language continues to be a point of disagreement up until the more recent publications on the topic. One example of this was Sawyer's (2016) publication, on which I based the analysis of my architects' interviews. In his original article, Sawyer (2016) concludes that *insights* are not part of the artists' *creative process*. I discuss Sawyer's (2016) underlying assumption in the context of the literature on *full insight* and *partial insight* (Koffka, 1936; Ohlsson, 1992), classification of *personal creativity*, *historical creativity* (Boden, 2004) and the *four C* of creativity (Beghetto & Kaufman, 2007). As a result, I suggest that the concept Sawyer used in his text only manifests aspects of the existing literature, but does not necessarily reflect the phenomenon of emerging solutions as researched in this thesis. Sawyer's (2016) dismissal of a possibly *sequential creative process* based on his use of the word *insight* seems premature, but not unusual for the observed ambiguous, equivocal, and vague use of the words in the literature. In section 2.2.8 I, therefore, suggest a pragmatic use of the terms for the context of this thesis and for future works dedicated to emerging solutions.

Insight is considered to be a part of creativity, innovation, and problem-solving. Based on the works by Rhodes (1961), Glăveanu proposed a classification of research on creativity that he called 'The Five A's Framework'. Glăveanu (2013, page 78) suggested using *actor*, *action*, *artefact*, *audience*, and *affordance* to situate research within the "system of symbolic and material human creation". Within this framework, the phenomenon of emerging solutions is part of the *action* or, to relate to Rhodes's (1961) well-known terminology, the *creative process*. In the literature I found two opposing approaches to understand the *action* of creation: a class of *sequential models* and the iterative *design thinking* (Howard et al., 2008, also see).

The theoretical foundation of *design thinking* goes back to cognitive scientists such as the Artificial Intelligence researcher Herbert Alexander Simon (1969). The basic assumption is that creative actors iterate through a number of 'spaces' or phases until the problem is solved. I showed a visualisation in section 2.7.5. The *design process* in one of its many implementations is part of the curriculum of artists, architects, and engineers. Since these professions are often considered to produce creative *artefacts*, I administered a study in chapter 3. The aim was to observe if *insight* is part of their *action* and if indeed *design thinking* can be used to trace their creative process.

The alternative, the prototypical *sequential model* of creativity was published by Wallas (1926) and consists of five consecutive stages as illustrated in section 2.7.4. Psychological tasks and studies often assume this underlying process. To assess the *action*, publications in Cognitive Science rely on measuring the *artefacts* or enquire information from the *audience* or about the *actor*. In this thesis, I introduce a novel experimental paradigm that provides information about the *action* of the creative process itself. The study in chapter 4 demonstrates that the observed physical dimension of the *action* links to the internal psychological experience.

5.2 A new multi-layered model

At a fundamental level, *design thinking* and *sequential models* differ regarding their visualisation as a circle or as a line respectively. Once the *design thinking* process has started, it keeps iterating cyclically through the same phases over and over again, until a final solution is found. Consquenlty this *action* is depcted as a circle. In any of the *sequential models*, the creative action starts at some point and progresses through consecutive stages towards the final solution. There is no repetition of stages in this linear process and as a result the *action* is represented as a line.

Models of the creative process are used in the education of practitioner. As mentioned earlier, the *Eureka experience* of Archimedes was initially written down in a textbook for architects 2000 years ago (Pollio, 15/1914). Von Helmholtz (1892) talked about his own creative process with the intention of helping others to become more productive and his model was later adapted by Wallas (1926). And *design thinking* has been used by creative practitioners and engineers since Herbert Alexander Simon (1969) wrote about it. The choice of the theoretical model informs the creative practice in how the problem and solution are approached. Teaching and applying the model best suited for the environment of the practitioners potentially improves the quality and quantity of creative products. The observation of the process, on the other hand, informs the theoretical model that is used in communication with the peers an in planning for the process. Therefore, the choice of the model has direct consequences on how the *actors* shape the *action*, and consequently on the *artefact*. If the process is perceived as a line, then then going back to a stage that was previously completed is difficult and as a setback, while the iterating through the same stage again is seen as progress in iterative models like *design thinking*.

Sequential and iterative models have previously been considered exclusive – the creative process was either sequential or iterative. As a result of my interviews with architects and taking into account the results of Sawyer's (2016) study, I suggest in chapter 3 how to map experiences previously discussed as a cyclic process on a *sequential model*. Visually, this means straightening the circle into several line segments. These line segments could then be arranged as parallel in time, and even organised in hierarchical layers. This has the advantage of defined start and endpoints, of a representation of the continuous progression on the highest layer of the hierarchy, and a representation of repeating stages throughout the *action*. Applying the multi-layered model of creativity to creative projects gives a higher explanatory power to the practitioners as they can account for observations more easily than in a sequential model. At the same time the processes within each layer are more predictable and structured than in cyclic iterative models. Applying the multi-layered model to educational settings gives students a framework to organise their own creative action in an effective and goal-oriented way, while obtaining the same flexibility of the *design thinking* model. This multi-layered model is discussed in greater detail in section 3.5.2.

5.3 Expanding the results of the interviews

During the interviews with architects, I found that they often work on several problems at the same time, or use techniques that allow them to manipulate several aspects of their work simultaneously. These different problems can be organised in hierarchies, such as the contextualisation of the whole building, section in a scale that shows the human experience, or details such as features of windows. Once these *actions* are transformed into *sequential models*, their arrangement in hierarchical structures allows a more detailed explanation of the reality. In section 3.6 I speculate on the nature of structural and temporal arrangements. In section 4.4.1 I observe the phenomenon of *immediate insight* in the data collected through *Dira*. While the temporal aspect of this observation is difficult to explain through a single *sequential model* or a *design process*, the subtask of a *multi-layered model*, as explained in section 3.6.4, can account for this phenomena. However *Dira* was originally designed as a hierarchical task, and it was only during post-hoc examinations that I found that the multilayered model could fit both the qualitative architects' data and the behavioural participants' data. While more data and analyses following up on sub-level as started in section 4.3.2 are required to provide additional empirical support for the multi-layered model, this model is currently the best fit for all these kinds of data.

5.4 Expanding the results of Dira

In the current literature, *classical insight tasks* and *convergent thinking tasks* are used to study the moment when solutions emerge. In both cases, the extracted measures are not based on the *action*. For example, in convergent thinking tasks, the total time to reach an *artefact* only measures the total length of the *action* and provides no information about the process itself. Individual differences of the *actor* mediate this measured duration. Current mood, language fluency, or fluid intelligence have previously been identified as contributing factors. As shown in section 2.4, for some tasks it is assumed that solutions can only be reached through *insight*. In other cases the *actor* self-reports as either experiencing or not experiencing an *insight*. This forced binary choice is then used to classify or compare the assumed *action*, for example by contrasting recorded neuroimaging data. The results from the *Dira* study show that human experience of the phenomenon is richer than this dichotomous assumption. In fact, people are capable of providing a reliable and consistent account of their experience. Reports from some of the architects, who talked about *Aha moments* of varying intensity, support this breadth of experience. For example, Lewis talked about 'bursting bubbles' as cognitive leaps happening several times within a project, Charles reported an 'Aha moment' coming up with the idea of a walled garden, and for Zak ideas began to 'click' when transferring knowledge from one year to another. Consequently, future research should take into account that *Eureka experiences* are not dichotomous.

5.5 Future directions

The results from the studies presented here open the way to a new methodology of answering questions on *insight*, *innovation*, and *problem solving*.

For example, *Dira* was designed with architects and creative practitioners in mind: the task contains verbal and visual cues, it has more than one correct answer, and the constraints are ill-defined and potentially ambiguous. Nevertheless, the task has not yet been administered to participants sampled from an arts or design background. In this study, *Dira* can be utilised to study the role of individual differences and domain-specific training on the *action*. Furthermore, modifications of the task itself, for example, adding or removing solutions or using more or less complex stimuli, can contribute to understanding the role of working memory, visual perception, and associative networks in the *creative process*.

The portability of *Dira* allows studying the influence of the environment on the creative performance. Contrasting data collected in the noisy group setting of an architect's studio with a silent and isolated room could be used to determine the effect of social, auditory, and visual distractors on the information acquisition process. Other modifiers of cognitive processes that have previously been identified as mediators of divergent and convergent production can be tested for their impact on the creative process as well. Examples are the influence of mindfulness meditation, intoxication, or mood changes.

When developing the task, one of the criteria was repeatability with the same participant. Besides applications in longitudinal studies, *Dira* could also be used in neuroimaging studies or to compare mouse tracing with eye tracking. In current EEG studies, the subjective experience of *insight* is assessed after the task, but the neuroimaging data is the only temporal data recorded during the *action*. Together with the non-binary scale for *Eureka experiences*, *Dira* allows more detailed analysis of the process itself.

The interviews with architects demonstrate that creative practitioners reflect on their work and their processes. The recurring theme of iteration and exploration indicates that the students act upon and report the process they are taught as part of their curriculum. The experienced and reported iterations could, therefore, result from confirmation bias. This hypothesis could be tested along with the effectiveness of the *multi-layered* model of creativity in a pedagogical intervention. In this study, a group of creative practitioners could be taught the novel developed model instead of *design thinking*. Their change of processes could be assessed through a longitudinal study based on *Dira*, and their performance in the tutorial through the regular grading.

Finally, the fine-grained behavioural data collected during the task execution provides more information about the human performance than previously existing techniques. This can be utilised in computational modeling of the creative process similar to the work by Hélie and Sun (2010), reducing the number of necessary assumptions and incresing the number of verifiable steps. Disassembling the whole creative action into smaller sub-processes by consulting the the multi-layered model, gives computational modellers more checkpoints to verify the effectiveness of their policy manipulation against the collected human behaviour. Therefore, the computer models are not black boxes with input, output, and unknown steps in between, but instead can be verified in between against data theoretically grounded in the multi-layered model. For example, in previous tasks participants are asked to press a button once they found a solution (Salvi et al., 2016). Hence there is no data to estimate what participants were doing before pressing the button and therefore no data to check intermediate results from computational models. The fine-grained data collected through tasks like 'Dira' (see chapter 4) provides transitional results, and the multi-layered model from section 3.5.2 gives a theoretical underpinning. Together they could contribute to more elaborate computational models of *insight*.

6 Conclusion

Creative solutions emerge as a rare and surprising phenomenon, which is often followed by positive affect. The agreement of two or more publications on the same theoretical definition or description of this event seems similarly rare and surprising, as I have shown in an innovative review of the literature. With this thesis I contribute to the endeavour of understanding the complex phenomenon of emerging solutions through an interdisciplinary approach: 1. I trace the theoretical underpinning across several fields, 2. observe and identify the phenomenon in real-life situations, 3. provide a multi-layered model to unify previously opposing *sequential models of creativity* and *design thinking*, 4. suggest an experimental paradigm to study not the resulting *products*, but the *process* emerging solutions are a part of, and 5. explain how people create in this novel task.

Several technical terms, such as *Eureka experience*, *Aha moment*, *insight*, *illumination*, *hunch*, and *epiphany* are regularly used in the literature of Cognitive Science. While I was able to demonstrate a tendency in how these terms are currently being used and suggest several interpretations of the phenomenon, the field is lacking clear and agreed on definitions. Publications often rely on everyday language when researching these phenomena. In chapter 2 I name ambiguous terms from different disciplinary backgrounds related to the phenomenon of interest. Historically I trace one potential cause for the ambiguous use of the term *insight*. Here I identify an imprecise translation of the German equivalent *Einsicht* through comparative linguistic analysis. With this investigation, I contribute to a better understanding of the terminology.

The research conducted within this thesis did not occur in a vacuum, rather I embedded it in the interdisciplinary research on 'Cognitive Innovation'. With the breadth of literature on the phenomenon of interest, ranging from psychological studies of neural correlates of *insight* to the education in Zen Buddhism and from social applications to artificial intelligence, the necessity to 'think outside the box' of disciplines emerged and seemed necessary to relate existing findings. My contributions to the framework of 'Cognitive Innovation' informed the research practice and methods used within this thesis.

The missing – or ever-changing – definition of the phenomenon makes it easy to dismiss its existence, even with clear and distinguishable subjective experiences of creative practitioners and problem solvers. By replicating a study with creative practitioners, I demonstrate in this thesis that the phenomenon of *insight* is part of the architects' work, but not necessarily of the *design thinking* vocabulary. In this work, I present compelling evidence that architects trained in *design thinking* experience *Eureka* and find it useful to include the phenomenon in reflections on their processes and practice.

I addressed the apparent conflict between iterative design cycles and sequential models of creativity in this work as well. Discussing the previously separated streams of research in a shared vocabulary, I propose a multi-layered model of creativity in this thesis. In this theoretical model, I organise sequences of creative problem-solving in hierarchies. This model, inspired by research from different disciplines, provides additional explanatory power to the data collected from architects and artists.

With the novel *Dira* task I propose an experimental paradigm to collect empirical data on the *action* or the *creative process* itself. Informed by the literature review, this seems necessary, since existing tasks related to the *insight phenomenon* often rely on the assessment of the *artefact* or *creative product*. In my literature review, I also identify measures that seem to rely on the *actor*, the *audience*, or the *affordance*. These previous approaches conflict with the assumption that *insight* is part of the *action* or *creative process*. With the task *Dira*, I demonstrate that the behavioural data collected in *Dira* can be used to narrow down the moment when solutions emerge. Furthermore, I show, that the multi-layered model of creativity I developed gives explanatory power where previously existing sequential models and design thinking fall short.

With the result from the *Dira* experiment, I contribute to the discussion in the literature between *insight* as a binary phenomenon or a gradual experience. Essentially, some research suggests that people either have a *Eureka experience* or they do not, while other studies give participants a more gradual response option. The interviews I conducted with architects show that they perceive cognitive leaps in partial problems as weaker *insights* than for final solutions. In *Dira* I was able to quantify this difference and confirm, that participants recognise emerging solutions not as dichotomous phenomena; instead, they were able to distinguish between different intensities of *Eureka experiences*.

Closing remarks

In summary, the phenomenon of emerging solutions is a fascinating and intrinsically interdisciplinary research topic. Even with the vast amount of literature dedicated to *insight*, *Eureka experiences*, *Aha moments*, *epiphanies*, and *hunches*, these subjective experiences of cognitive leaps seem to lack process-based and systematic exploration. Considering 'Cognitive Innovation' as a theoretical underpinning for the interdisciplinary work provided a useful way of thinking about the individual, societal, and technological aspects of the *Eureka moment*. Furthermore, the methodology and terminology spanning several traditional disciplines allowed a novel and useful way of approaching *insight*. The mixed-methods approach in this thesis resulted in a novel theoretical model supported through empirical data from a novel task and observations of creative practitioners. Future research is invited to build on the experiences of the *Dira* experiment in the quest for the *Eureka moment*.

Future

There is a range of future research on the emerging phenomena that would interest me. The *Dira* task could be modified to measure other aspects of the creative *action*. I believe, neuroimaging can be used to identify the brain networks involved in solving the task. This would allow to identify brain activation correlated with the behavioural data to strengthen assumptions on thought processes. Given the opportunity, I would want to use these different data sources to advance the computational models of *Eureka moments*, for example building on the epiphany learning research, and therefore the time course of emergent phenomena in general. On the theoretical side, I want to explore other implications of 'Cognitive Innovation' as the framework that enabled this line of research and to think and work outside disciplinary boxes.

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Appendix

1 Transcripts

1.1 Interview with Joshua Watts

Frank Loesche: What I am interested in is: How do you solve problems in your domain? And to start with: What would you consider a problem?

Joshua Watts: So you mean in architecture, or in architecture school?

Frank: If there is a difference, maybe you could explain that?

Joshua: I guess as a start — its designing versus site analysis and looking at it. Well, if it is going to be within the budget...

So if we find any kind of problems or issues with its going to become almost like a stimulus or stimuli to emphasize upon.

Frank: So you would basically go to that place and experience...

Joshua: So as is said: my site is on the Barbican. So you could say "There is not enough connection to the water". That could be a problem.

Frank: Who tells you that not having a connection to the water is a problem? Is that part of the task you are given?

Joshua: It's more like a personal analysis, I guess.

Frank: So you try to put yourself into the place

Joshua: ...and then you can speak to the people as well and see what opens up. Although I would say with a person it's more an individual site analysis, and then developed upon what you think the problems are.

Frank: And you basically try to get the feeling of the site, understand the place. Do you have any other constraints — and why do you choose the site in the first place? How do you make it your own problem?

Joshua: Personally, well — the site that I chose I chose because there wasn't much activity, there wasn't much going on at the site. So I wanted to kind of revive the site itself and then use the building to create some kind of presence to make it want to go to the place rather than just walk through.

Frank: So the motivation is to change things?

Joshua: Yes, to use architectural design to make like a better landscape, trying to improve existing regions.

Frank: Do you want to make yourself being seen in some way- is that part of your motivation as well?

Joshua: I think so. … I don't know. I think each project, everyones project is quite personal. So yes, I think architecture school itself is a good place to test yourself, your own ideas, do things which might not necessarily be viable in a real world, but can still provide like a good testing bed to try things out. I guess from that actually an idea might spring out.

Frank: So it's more about learning how to approach things?

Joshua: I think: Yes. I'd say, it's more of a learning process rather than necessarily doing something what is completely understood. It's more like learning how the design process works.

Frank: What did you learn then in this tutorial? Is there something you can pin down like "I was down there one Sunday, the sun was shining or I had a chat with some friend and then suddenly…"

Joshua: What we are doing now is some kind of a development of something we have been doing last year. And we have this site, which is a car park. We developed into this kind of public urban landscape. So for this project I have then chosen the site next to it. So I want to develop that into what we have done last year. It's more of a development of the things we have already done rather than "I spoke with someone about this space specifically". Just another place I have identified and have developed.

Frank: Can you name a few days that had a impact on your work or is it more like a steady flowing process: you start at some point and the more work you put in and the more time you put in, the more you will actually get out. Or is it more like: sometimes you solve more in one day and sometimes you solve less?

Joshua: I think, there is definitely, I am going back to lasts year, but there is definitely some days where something just clicks and you just have an idea. And from there you just develop it and you keep working, but since then it has been a fairly steady flow. You start off with fairly sketchy designs, and then you are refining those until you have a building. From there you go down in scale so you start looking at it in more detail how it starts to go together. So I'd say there are times, there are days when ideas click and from there...

Frank: And once you change the scale to ... is it scaling down when you go closer?

Joshua: It's scaling down.

Frank: So if you change the scale, how does that help?

Joshua: It gives you more, for me personal, it gives me more — knowing about what I am designing. The more detail you look into, the more you scale down, the more you know how the building is going to go together. The more elements... I am making a 1:20 scale. So it's quite big, and it's just beginning to show how exactly things are going to go together. Well say, a few months ago I was more looking at sketching at a plan. Without really knowing how it might look or it might go together.

Frank: So what changes if you take a sketch out and put it into a model? So what is the difference between a sketch and a model for you?

Joshua: So personally I use models to show more of how the building goes together while the sketch is more of a form, maybe where different rooms might go. So let's say there might be a room here, or where the roof might go. But when it comes to a model it's not really about showing these different spaces. It's showing how the whole thing is going to go together, how it might look.

Frank: By "showing" — do you mean in a way of communicating with others, and communicating with your group, or with your tutorial? Or do you mean for yourself, show it to yourself?

Joshua: hm...

Frank: I mean if you were asked just to build the building — would you need the model for yourself or is it something to communicate with others?

Joshua: They do help me a lot, personally. I used not to like the models... Models communicate to other people much more than just drawings. When you do a sketch to yourself you just see where you're at while with the model it more like a still frame. And obviously in architecture, buildings are 3D itself, and sketches are not.

Katharine Willis: When you do a site analysis, it might be useful to mention how you do that with drawings. Frank might not know that you are actually getting lots of drawings as part of that process, so it's not literally just walking down there.

Joshua: Site analysis is a process. A lot of it is taking photos, a lot of drawings on site. And then a lot of examining along the site. And sketches and everything. Just to kind of giving yourself as broad of a picture as you can. But then it can expand out of the site, so you look at city scale problems. So in my project I am looking at the lack of green space in the city. So that is something that isn't necessary just looking at the site I am building on, it focuses on a wider problem and trying to use the building to encourage the introduction of more green space into the city.

Frank: Does that also mean you look at the history of this place.

Joshua: A lot of people do that, personally I haven't. That could be another stimulus for designing. The history of a place and what has happened on a site in previous times. You could try to reintroduce things that have happened before back onto the site. Kind like the train line on the Barbican which isn't used any more but some people trying to kind of reintroduce that.

Frank: Do you choose what to look at or is it something your task tells you?

Joshua: There are lots of different assignments, so it kind of varies where you're from. But within the assignment it's very open what you can look at. So you can make your own assumptions and site analysis.

Frank: So for example the choice not to look at the history — that is entirely your choice not to do that?

Joshua: Yes. I just thought that — history is the history. I wasn't actually too interested into examining that.

Frank: You said it's more like looking for a stimulus that actually influences your work. Is there something I am totally missing?

Katharine: People from different units will have different input. You will have a certain input that is given, a document with what's defined, what's not defined.

Joshua: There are certain things everyone has to consider for the final presentations.

Frank: Thank you very much.

1.2 Interview with Ewan Palmer

Frank Loesche: I am interested in the whole process, how you approach the problems that are given. What would you consider to be a problem in your work throughout a tutorial?

Ewan Palmer: I suppose finding a solution to whatever design process you've been through.

Frank: So who put the design process on you? Who decides what problems you ought to work on?

Ewan: It's part of the assignment. You have have to hit certain criteria, like 1500 square meter building that has to have at least two floors. Do whatever you want with that, really. I guess I just mainly go through drawings, draw everything out. Try to think. Once it's in my head then I try to get most of it out on paper so that I can see it physically.

Frank: So if you hear "I have to build a 1500 square meter building with two floors" you immediately start drawing?

Ewan: Yes, start sketching out first ideas. So it might be really basic. And then move from sketch drawing to something a bit more solid. So it might be like a plan that was drawn out at the drawing board. That won't be perfect. So I'll make iterations about it until I get into it.

Frank: So where do you get your first initial idea from? I mean, looking back at it what you have done in the past, what do you think was the inspiration or source for that?

Ewan: Various things that I have seen and experienced. Taking inspiration from memory, I suppose.

Frank: Would that be something you have seen recently or does it not really matter?

Ewan: Things that have happened recently — probably more. They are more in front of your mind, so you might be more influenced by this. But it wouldn't be specific to the most recent thing you have seen.

Frank: Does it matter where you put your building? If you just hear "1500 square meter building" it might be something different to put it on the Barbican than just next door, right?

Ewan: Yes, obviously. You are given some sort of site. At the moment that's Exeter.

Frank: So understanding that is obviously the first task?

Ewan: Yes, obviously the surroundings have an influence on what you are thinking about and how you come up with your structure.

Frank: So did you start drawing before you actually went there? — you obviously go to that place at some point, right?

Ewan: Yeah... No, not really. The first thing we did was visiting the site. I suppose you can take inspiration from that as well of what's already there, what's found.

Frank: Do you try to follow the form of the place or do you try to rather contrast it in some way?

Ewan: Well, I think it depends. It depends on what you are trying to do, what your agenda is, what the idea is...

Frank: So which project are you working on at the moment?

Ewan: At the moment the Exeter Quay.

Frank: What was the general idea of what you want to understand in this tutorial?

Ewan: Exeter Quay is like an abandoned boat yard, it's every once in a while flooded. So it's about safety considerations in the proposal.

Frank: Do you just try to secure it then?

Ewan: It's about bringing the site back to the city. At the moment it's very separated from the city centre itself. There are good connotations and bad connotations about that. We always talk about "stitching things back together". I am looking at, whether that would be a good thing or a bad thing. And how individuals can basically change a city, can change something.

Frank: So you are looking at the social scale, gentrification?

Ewan: It's sort of a mapping to the idea of people creating a city rather than institutions. So where people work with the city might not necessary be the main part of the city. And why is that? What influences that? How does this adapt? How does it change the city? How does the city adapt to the person rather than the way around?

Frank: How can you help that process with architecture?

Ewan: At the moment I am trying to use the idea of agencies. I give the individuals agency to create their own spaces. At the moment I am mapping each individual. And their individual map is displayed which effects a wider populous of designers and architects who are effecting the city directly and physically. Then they are influenced by what the individual is doing rather than by other things.

Frank: Are those individuals people you actually met at the site or are they more like personaes that you created.

Ewan: Yes, they would be if it was actually a live project, but in this context, you know...

Frank: Why is that important and how does that help you?

Ewan: To me it is more of an agenda rather than... I think that cities at the moment are very verbalised and not focused on the individuals that occupy them. So I almost try to fight against that process that is happening at the moment.

Frank: So how do you do that?

Ewan: So it is about the idea of agency again, the mapping, influencing the people who are influencing the city directly. Like architects. They effect the city by building and constructing stuff, but you effect those individuals and you give the individuals more agency than they would have initially.

Frank: So do you give them space, or do you give them a building?

Ewan: You give them a connection to the people who effect the city directly. Take from them what they think about the city and how they use the city and people who directly act, like architects, get to see that. And that, in turn, effect what they do to the city. It's about the relationship between those two.

Frank: Was there anything surprising in the current project for yourself? I mean from your perspective, or was it a rather smooth experience from your first encounter...

Ewan: I don't think it was a smooth experience. I think there are certain points in the process where you try to work things out and then suddenly, how do you say "Eureka moment", you jump a bit. And then you have like another plateau where you try to think through things and work through things and then again, you sort of jump again. Do you know what I mean?

Frank: Yes. Why do you stay on a plateau? Why don't you just continue in progress? What do you think keeps you from doing so?

Ewan: I think it has to do with the way I work, getting things onto paper, getting things out physically. Having a bit of a making process. So you might be doing something that you think is useful initially but maybe it isn't and then you change what you are doing. So you might go from drawing to modelling... I think you have to find the right media to solve the problem that you are trying to tackle.

Frank: There is a different medium for each type of problem I suppose?

Ewan: Yes. It's hard to identify, I suppose. Sometimes you might want to work on two-dimensional forms, just drawings. Sometimes that wouldn't work. So you wanna work in three dimensional form like modelling, or working on a computer. That's not three dimensional, but it is seen three dimensional.

Frank: How do you know it is the right medium?

Ewan: I suppose you only know once you've come up with the solution.

Frank: Why do you know it's a solution?

Ewan: I think it's about how you perceive the solution. It might not be the right solution to everyone, but it would be perceived like that.

Frank: It is more like a feeling then?

Ewan: Yes.

Frank: And changing the medium... I mean if you knew you could solve the problem using a 3D computer model, would you still start drawing first and doing a model or would straight go to the...

Ewan: Yes, straight. I personally would. I always try to use the medium I think would solve the problem, sometimes it just doesn't and you have to change how you work, adapt.

Frank: Thank you very much. Just one final question. Do you think it helps to work in groups or do you like the individual tasks better, to show what you have done yourself? Or is it more helpful...

Ewan: I think it is easier to work as an individual, but it is interesting to work in a group to mix agendas. Trying to solve things as a group. It is definitely harder because each got a different idea and each trying to get to the solution, but your solution might not be the same as theirs.

Frank: And you tried to work in different groups, right? Which one was easier?

Ewan: I think smaller groups. You start off in groups of six or seven and now in groups of four. I personally think four is a nicer number, just a little bit easier to get on with everyone.

Frank: OK, that's it. Thanks again.

1.3 Interview with Alex Wells

Frank Loesche: Like I said earlier: I am working on creative problem solving. I am really interested in what you think is a problem in architecture? What are you trying to solve here?

Alex Wells: I think you don't really know what the problem is to begin with. It's almost like you are looking for a problem. Maybe it's not a problem, maybe its something... a quality which is uncertain in that. That is the problem that should be presented or highlighted. I think it is totally subjective to where it is, I guess.

Frank: What do you mean by uncertain quality?

Alex: There could be something really unspoken of or really positive about a community or about a landscape. You know, whatever it is, sometimes more, sometimes less... it should be highlighted, it could be highlighted. It could be better for the wider context if it was highlighted, but it is not. So you highlight it.

Frank: How do you find something that is worth highlighting?

Alex: I don't know. OK... Sometimes it's just like through inspection, or sometimes it's back to nothing...

Frank: Do you have an example for that? I mean coming from the outside of the field, it's kinda hard...

Alex: Yeah. I don't know. I think the idea of back to nothing is like. It's not really talked about that much in architectural approach. So maybe I am there, stuck in the project and then just, accidentally, I go somewhere else and for some reason... by going there it brings something to look back at the project differently. So it's just pure coincidence. I talk to someone and it just happens that they knew someone who knew someone that...

Frank: Is that you main approach then?

Alex: No, definitely not. It's just like... No it's just — if you have a dead end it helps sometimes.

Frank: Why do you end up in dead ends? I mean, if you say, you usually have a different approach to problems...

Alex: I don't know. I think sometimes you just use momentum I guess, if it happens that you sort of getting there. Other times you just try to be creative, I think: just working in many different ways. Sort of juggling everything. And then you solve by juggling with yourself. Sometimes you just need a chat with like minded.

Frank: So your usual approach is "juggling", and every once in a while you have an "accident".

Alex: yeah. And then you drop everything...

Frank: How do you feel about the juggling process itself. Is it kind of frustrating to start with this process and looking from one to the other.

Alex: Yes, it's kind of frustrating, but you know it is frustrating. So you accept it.

Frank: So you start and you know it will frustrate you...

Alex: Yeah. So you know that. Because you end up spending so much time on one and then you know when you move on to another thing it's gonna be great and it's going to change completely. Does that make sense? So constantly, everything you make, you almost know, it is not going to be the same after the next drawing you are going to do. So for instance you do a drawing and you use something else, and you go back to your drawing, it's bound to be different. So you end up redrawing everything. So that's kind of frustrating, and that's sort of juggling a bit. Every time you touch something, next time you touch it, it's completely different. So it's always changing.

Frank: Isn't it some kind of steady progress then?

Alex: Yes, yes, it's definitely progressive.

Frank: Why is it frustrating then?

Alex: No, it's good, because it is progressive, it is frustrating because it takes a lot of time. No it feels good to touch it again, but I would still say it's frustrating.

Frank: OK, this approach was the juggling one, the other one was the accident.

Alex: Yeah. But the accident is very, like...

Frank: How often does that happen?

Alex: I don't know.

Frank: On a weekly basis, one time a year...

Alex: No, no. Maybe a few times a year. Or even just little things, you read something you wouldn't normally read or you watch something you don't normally watch... So in that sense, those little things... They can happen on very small scales and on very large scales. I guess it could happen all the time, though... We are just not conscious about...

Frank: Could you give me an example?

Alex: In the last project, it was at the time when you are trying to present everything. So you are there. You know that the next project after is basically already developing. So this is like the middle, this is presenting where you are. And while I was working on those I went to a lecture about a Montreal based landscaper who was just talking through his approach to landscaping in a community. And from that I saw all the floors in my design at the moment. Because of the deadline I knew I couldn't change it in time. So just kept that in mind and now, once I handed it in and I got back to it in January, it is much like — I am having all those new ideas that coming into design and developed it. So it is just like an accident that I listened to that, but I just hold it now came back to it in time.

Frank: That happens at small scales as well?

Alex: Yeah, I think that was more of a small scale. A big scale would be, I don't know... Architects designed a building which wasn't meant for this client, but then it turned out that the shape, the form the building ended up in having a representation of that Chinese symbol. So they saw the building and they said — "Oh, so is that our building?" And they said "No?", "But that represents this in our language..." From that, from this accident they designed a building that represents something to them. That accident, or that accidental view, made them give a building to them.

Frank: Besides small things adding up you also said that you work with different models, like drawings... How does help you?

Alex: The same idea of juggling. You work in one medium and then you trying to translate it into another medium. But through that translation it develops. So if you do a drawing of that space and when you do and try to replicate that space in this new format, you see those floors in that space that you created. And then develop those problems. I don't remember how you identify the problems, I think you just "know" the problems. I think through that translations you just see... It doesn't necessary convey what you are trying to say.

Frank: So if you translate it back to the drawing then would it be different?

Alex: Yeah. So when you are trying to translate it back you look at it completely different. Maybe not entirely different, but bits have changed.

Frank: So a good way to solve all your problems would just be to make a model, drawing, model, drawing....

Alex: Yeah, yeah.

Frank: Is that what you would do?

Alex: Yeah. But it’s not always just like alterations between models and drawings. It doesn’t have to be physical. It could be writing. So you write about the space and then you realize.

Frank: So how do you identify the type of problems for example that makes you want to write about it?

Alex: I don’t know. I think a lot of help is to … I think that’s when the work comes. The work is when you don’t know where to go. So you don’t know whether to make a model, make a drawing… But nothing is changing. That’s when you start talking to other people or start getting your inspiration from other people. Through that, you say I want to try this. Also it’s about what I feel comfortable with. Personally I rarely write about my work because I am not very comfortable writing. While a lot of people do and through that. I don’t even know how you decide what kind of hierarchy you pick yourself in terms of doing drawings more often, making models more.

Frank: Could someone just starting, like me, follow your path to solve the problem? Or what would you suggest? What is the difference there?

Alex: I think it is a process of you knowing how. I mean, the way I work now wasn’t the same as I worked last year. It is a lot more efficient. And I am sure, by the time next year, I know how I work a lot more than how I work now. The same, if you just started, you would probably, in a very simple case, draw out something. Or maybe not, because you might not know how to draw. It also goes back to your background. But it’s also about how I was brought up, the education and how I was taught…

Frank: Would you say you get inspiration from other people? Are those architects as well?

Alex: It could be anyone. I mean, I talk to my mom about projects and she goes “what about it”… You know, she is a nurse. She has no clue, really. It’s quite nice when go outside of the insula of architecture. You know, talk to real people.

Katharine Willis: It strikes me, how students work — it’s more like a skill. You basically gained the skill, knowing how it works. I think if you came in and did a project, you wouldn't have the skills to complete it. You might be in the same process, but there are some skills that you have to have to complete that. So it's not just the task itself.

Alex: Yeah, that's because, you have gained that through experience.

Katharine: I think that's the point of experience. Because you are basically repeating the same process pretty much all the way through your project while you are doing different tasks. So it's sort of a repetition, but it's a different condition, basically.

Frank: So how does the tutor help, or what is the role of the tutor in this process?

Alex: It sort of takes the same role. It is an outsider person coming in but also they take the role of a tutor in general. So they make you do things that you wouldn't or haven't even ever done before.

Frank: Just within the architectural domain or do they also take your thinking "outside the box"?

Alex: Yes, definitely. This year... I have never really been political or economical and then, this year I have put that sort of perspective on every step... So I shifted to be more politically. I think it's probably from the tutor or more current events or things like that.

Frank: So what is your tutorial, what site are you working on right now?

Alex: in ... Island...

Frank: Thank you, that was very helpful.

1.4 Interview with Kiera Stanley

Frank Loesche: Maybe first: in which tutorial are you working or what project are you working on? Can you describe what you are doing at the moment?

Kiera Stanley: OK, so I am working in Plymouth which is a car park. And I am designing a proper boat building and a pub for the community.

Frank: What kind of problems do you see or how do you get engaged with the project, how does it start?

Kiera: I don't know. It's not really like a tangible thing. You get inspired by something and then this motivates you for a while until you hit the next wall and then, I think you have to — for me it was so — when you always think about it, when you always think about the next part of the project you just keep having ideas. And then you just want to make them visible on paper...

Frank: How do you chase up those ideas, how do you get creative? Do you have a special technique for that?

Kiera: Generally, I don't know. Probably getting out of the studio. Well for some of the ideas. Sometimes when you are in a place where you can't get an idea you just need to clear your head and get out and get some fresh thinking. Which just means being in a situation which isn't as relevant to what I am doing.

Frank: So is this something completely different?

Kiera: Yeah!

Frank: Or do you actually go to the place ...

Kiera: Oh, sometimes I do. I quite often go for a run and I run past the site. And that kind of helps. What am I trying to think? It's just running around...

Frank: What are you trying to change in that place? Why are you trying to change it?

Kiera: I am trying to change it because it's kind of a forgotten location in Plymouth and there is no real need to go there. And also doesn't seem to have any meaning or character. And so I am trying to bring some of that meaning back to a real building. And that's why I think it is more important to have ideas rather than just design something just because it has to be something that is more meaningful to go to this space.

Frank: How do you know it will be more meaningful? Is it you personal point of view that matters?

Kiera: I just think it's personal. But I think that it's something that has a bit more input. Like something... for the people... who might think this is just a car park. It's not like you would like to visit something like a car park. It's something that kind of intrigues me.

Frank: I mean the car park itself has a meaning to the car owners that go to places nearby. So you could argue it has a meaning. Who decides that you want to change it to open it to others as well?

Kiera: I suppose it is generally... the function of a car park is this utilitarian thing. It doesn't really have any wider influence on that. It is not really good for anybody other than the people who are moving. Nobody else would see someone driving a car in there "Oh that looks exciting. I should do that." I mean it's not... It's just a function.

Frank: I mean it probably has influenced the neighbouring areas. Someone who wants to go to a nearby place will drive there.

Kiera: Yeah, I mean.... That's how I think it has a lot to do about scale. Kind of a wider connotation. I think the thing to do with meaning... [Interruption]

I think what I am trying to do, what I am trying to put in is something that creates some kind of local interest rather than something thats on a different scale. And a car is something, you just don't get in a car for a ten second drive. You get in the car to go to Dartmoor or something. So it's kind of a local... And that's something that a neighbour will benefit from rather than having a car park.

Frank: So basically you change the scale of looking at one particular spot. You changed your scale when looking at it. How do you identify problems within that space? Do you talk to neighbours? Or do you go there?

Kiera: Yeah, I mean. During this project we talked to a lot of people. Drivers, and a couple of nearby businesses, and asking them what they thought of the space. And the most interesting thing was talking to a guy who runs a pub and he was talking about all this history. There used to be an emigrations. People who go to South Africa, and Australia, and America... and all the people just parking their cars there would be completely oblivious to that fact because it is just a convenient location by the water and so... it was something about the building also kind of really activating something completely forgotten as well...

Frank: That is something you are trying to do now? Reviving the history?

Kiera: In a way. I mean history is all about the sea. And I am working out ... so it's just about bringing back that dimension.

Frank: One of sources of the inspirations seems to be you running around in that area, another one is the history. Are there other influences you could identify at the moment?

Kiera: Well, I think it is slightly selfish, really. But I am doing things from ideas I had on previous projects. Like "Oh, I wish, I could do that" — but it didn't work. So it's in a kind of agenda to think "Oh, wow, last year I really wanted to do that" and so... probably from a kind of selfish perspective...

Frank: Is it about building your own skill set in a way?

Kiera: Yeah, definitely

Frank: So what kind of skills do you want to learn?

Kiera: What I am aiming at is to produce things that will help me in the next stages. So when I look at a piece of work I like "OK, I've done that and I cheated about that little thing there." And I can put in more effort for follow ups and I am really up for that. In a completely different setting. Perfecting one project in one style... Lots of thoughts and feelings, but I can dig it up later on and look at it and think "Oh look, it got this and it got that... and then I just make one thing"...

Frank: So you are trying to build your portfolio at the end?

Kiera: Yeah!

Frank: Are you trying to test yourself out what you are good at? Are you more considering on learning the technique or try... Or is it more important for you to have solved the problem or do you want to put your name on the map of Plymouth?

Kiera: I don't know if I really care about putting my name here. It's not that I don't want to... What I want to achieve is more about having some skills that I can apply to building a name for myself. But I mean the skills, I just need to build them more on the computer whereas a lot of people are much better in sketching. And so I also recognise where my strengths are. Especially last year I tried to be good at everything. And I approached it. I did everything. But I knew I want a variety of visual styles, but I didn't know methods will get me there that I am better at.

Frank: How do you get better in those methods? Does it help you to produce new ideas?

Kiera: Yeah. Exactly! Because the process of putting it down is quick and I am able to not worry about how to represent. You just have an idea and then communicate that idea, put it down. And that really helps.

Frank: Is it just about the time or is it also about the effort you put in?

Kiera: It's about time. Cause sometime you spend so long trying to work out how to best represent a thing.

Frank: So is a main constraint for you by solving a problem the time? Or what is it in this tutorium? What puts the most pressure on you?

Kiera: Yeah, I think when you have a deadline or a time. Then you tend to have more ideas and you will try things and just see if it works.

Frank: So you are saying when you have a deadline you have more ideas?

Kiera: In a way. Because you know the deadline. And you then take your time and kind of ... the ideas kind of evolve. I try loads of things and I quickly see if it works.. And then I just do one of them.

Frank: So how do you know which one works? I mean, it's probably not like in math where you know 2+2 equals 4?

Kiera: [Laughs] No. I mean. I don't know. Sometimes when you have one thing... For me... I guess at some point you just need the justification from other people, you need another perspective. Gosh, I wish I could do this or that and all from different pieces, of if you do this from this. And it's kind of... and then at some point it's just like "Wait, that's much better"...

Frank: So you say the group is quite important for you to solve the problems?

Kiera: Yeah, in a way...

Frank: Not so much for creating the idea

Kiera: Not so much for creating the idea. I think if you spend time with a problem quite long, you can't really stand back and need a fresh set of eyes to look at it.

Frank: Do they have to be "trained eyes" as well or do you show it to your friends

Kiera: I guess to some kind of extend that helps. I mean when you have a group of people and you are always working with them they kind of know what your ideas are, anyway. And so they go "Oh, do this, this relates to your other thing you are doing." So having people that are familiar with it helps.

Frank: Familiar also with the project or just with your methodology? Probably you know what the others in the tutorial are doing, right?

Kiera: Maybe other people are aware of parts of my project, but not as much as I do...

Frank: Did I forget anything?

Katharine Willis: Just a little thing. Say when you are showing it to your friends and you were explaining it like, this one little room is going to be two little rooms. I guess you could explain it to someone else, but if you could show it to someone else, lets say you have a plan, or more a sketch... People, you know, there is a level of ... they are not trained in a way to read that information...

Kiera: The question is if you have a really rough sketch up with much of the lines just going everywhere and I say "Oh, this room is going to be great". And I didn't have the people that are always here, they probably would be like "That's not a room, that just a..."

Katharine: But also just the language of drawing, sometimes is not... You do need a level of knowledge to understand what those things will look like. That might mean it's a line, OK, but it actually shows XYZ. So I think, that sort of level of tacit knowledge about drawing styles or ways of working how to represent...

Frank: So is the drawing actually for yourself to understand the problem better?

Kiera: Yeah, I think I aim mainly for myself. And so that's why it helps other people that are familiar with the way that I do my work... Because when I am doing it for a broader audience, it will be much more finished things and I will do them very differently from when I was doing them for myself.

Frank: So you have two different drawing styles, one for developing ideas and one for selling your ideas? It's like two different languages?

Kierw: Yes, definitely. It's like a framework and then I polish it up...

Katharine: There tends to be a format where you present your finals... which are tend to be done later in the project. We encourage them to do them early, but they tend to be done later in the project. And there will be a set called "Working drawings" which is the step to be presented and people will flick through, but they are not meant to be finished.

Frank: So only the last ones are laymen's audience?

Katharine: Well, I think both of them are still for an informed audience, but there is a level where one is something that is complete, one is still drawing stuff here... they are called working drawings, you are still working on them. Both need a level of reading skills. But probably for the working drawing knowing more would help to know OK, that's part of this...

Kiera: Yes.

Frank: Thank you very much....

1.5 Interview with Lewis Vaughan

Frank Loesche: What I would like to do is: let you explain to me how you are creative.

Lewis Vaughan: My creative design process?

Frank:Yes, how do you do that?

Lewis: I am probably one of the worst examples you can get for a good design process of all these over at Architecture. Because one of the things I picked up from this. When you come from GCSE and A-Level creative subjects like Art or Graphic Communication, which I did when I was sort of younger, there is a real sort of lean or direction around conducting one sketchbook. Which is the perfect, idealistic looking sketchbook with everything perfectly ordered, pretty, and flaps coming out of them, trying to present and display your process as efficiently as possible. Which I totally understand at that stage, because that's one key component you need to continue through the design process. In a way to present your ideas to the examination board. But it does push a lot of students down that sort of perfection route, trying to make everything absolute finesse. Which is... it can put a lot of pressure on the student, a lot of pressure. I'm one who struggles with anxiety and stress. And the creative process is the worst sort of beaten by that.

Frank: Why did you choose to be an Architect then?

Lewis: I don't know. It's just... I know. I should probably lean away from it. But it's creativity is something within me, which I feel I have to justify for the future. It's something I do have a real passion in when I am really into it and when I am doing things right and when I am into perfecting things. But when I'm not, it can really sort of bear down on sort of, how you are feeling... and stuff. And so, I have kind of gone down that perfection route, which isn't the best. Yeah, Creativity... I mean it's terrible for some people, because it never has any limits to it like in other academic subjects as science or English, or maths — there is a right or wrong answer in some cases. Oh yeah, the question. As for us the subjects we are doing, or the exams, there is a short right or wrong answer, whether you pass the exam or not. While with creativity its a much more personal thing. There is no limit on the amount of work you put in. Yeah, there is no limit to creativity. Which is great. It's exciting. But it can be sort of stressful when you want to put a limit on it and you want to come to an end.

Frank: So how do you find the time limit then? So when you're working through it...

Lewis: I don't know. The problem is. I'd love a 9-to-5 job, but this course... Even though I might not be doing a lot of work, I'd be constantly thinking and thinking and thinking about my process. And some in the studio say they came up with the best ideas at three in the morning when they wake up in night terrors about their work. But they have an incredible idea ready for the studio in the morning. And sometimes it is when you get into a general flow. And you could be in the studio and you think: "It's six o'clock I gotta go home, I need a stretcher, have some tea, get to the gym, have a bit of a down time". But you have got one idea and you need to sort of justify it. And that's the same. You are looking on that scale and then on the whole thing. As I said earlier, I wanted to justify my creative inhibition almost. I feel like I need to see how things go.

Frank: How do you approach a problem in general? So if you are going to a brief, what are the first things you are doing afterwards?

Lewis: Well, it's always been taught in all the classes to go through a simple process of analysing the brief, doing initial research, maybe going back to the brief seeing how that reflects on the brief.

Frank: Do you actually go to the places? Did you go to the site and have a look around?

Lewis: Oh yes. This year is the first year, actually we did it at the end of last year. This is only recent that I have a site attached to one of my projects since I only plunged in recently into Architecture. Yeah, that is one of the most important things, I certainly found it in this project. As you go to the site and you really immerse yourself into the environment and you really need to understand the environment. And there you might not be doing direct research of how many bricks are on site, how many lamp posts are there, how many people are there on time. Well, amount of people matter.

You need to get a real feel for the space, you need to, it needs to… If I did a project on my house right now back home, it would probably be my best project I ever did. Because I know it so well. As its not knowing it through facts, it's knowing it through experience. And that's one key factor about Architecture, it's always about the personal experience in this place.

Frank: If you put out a draft or a model, is that an externalisation of your internal thought process or is that too big of a claim? How do you see that yourself? Is that you somehow made out of stone, or is that something completely detached from yourself, but sourced in your personal experience? What is your relationship to the thing you create?

Lewis: That's the frustrating part about finishing the project, trying to put it out, trying to capture what you thought, what was going on in your head, because I think that's almost impossible to do. I've never been particularly proud of any of my projects because I feel like they don't justify the space I am trying to create or representing the space that's already there. I don't know. You could spend every minute, second of your life trying to do a project like that, and I don't think you can capture your thoughts in stone, as you said.

Frank: How do you approach the project then? Do you just have one piece of paper and sit down to sketch?

Lewis: Lots of people have different processes as you will probably find out asking everyone. Some people upstairs are a lot more structured about their work and they can say: Alright, I need to produce this model, just get on with it. And they start making the model. Some people would sit there thinking consistently and then will do something in the very last minute, but spend a lot of time considering what they are going to produce. And then you have me. It's a bit of a Mad-Hatter. I'll get so stressed at this process of the design project. It's… no. For me it doesn't fit any more. Ideas spring out of nowhere. So my process is getting a piece of paper and scribbling an idea, drawing a cross-section of an idea. And I sometimes jump to the very end process of design. And will do what I consider like a final cross-section sketch. And then that gets screwed up, or reconsidered. And I admittedly think it's just best for me to be fooling around. One thing: never fight your individual design process. And I think that's why a lot of our design briefs can be quite ambiguous. That's because everybody is completely different the way they design. And so to set these sort of loop holes for people to jump through. Or: "OK, I want you to produce these amount of models on this day and I want you to produce that on this day, and this cross-section on this day." It doesn't... Well sometimes tutors find it useful to get that structure out and the work out and work under pressure. But sometimes, for a good designer, it doesn't necessarily work out.

Frank: For yourself, at the beginning of the year you start working on something. And whenever you have the feeling you need to jump...

Lewis: Yeah, I meant that's why I brought my sketch books. 'Cause you'll see, I just literally start scribbling away. I mean this was from third semesters project where I did try to go in a linear fashion of analysing the site, and then moved to the other side. This is when I got myself a pretty neat sketchbook. But then I just started skipping ahead to the end processes and ideas, which I should choose at the very end, but I touched base on them. And this is just sort of scribbling out. People tell me off for spending so much time in my sketchbook. But it is... a very helpful process to get all your mind out just one booklet. Otherwise you'd find me scribbling on this paper, chucking it all over the place. I can't collate it all. But yeah. I'm just going through. I find it quite easy to jump up and down the ladder of the design process.

Frank: What do you mean by jumping up and down the ladder?

Lewis: Like I was saying, the tutors are trying to get you go through this initial idea, research, development, go back to initial ideas... Where as I'll do sort of final ideas, jump back to research, jump back to initial ideas, panic, do a little more research, jump to... So that's why jumping up and down on sort of a ladder... But me, it's all about just having the ability... I don't know...

Frank: I see a lot of different type of drawings. What is this for example?

Lewis: That's axonometric. When everything is on a 35 degree angle, but that drawing is exploded...

Frank: And what is this? A piece of a wall?

Lewis: No, this is actually a bee-hive. It's been from my last project. A bee-keeping, kind of a archive and research laboratory which also integrates disadvantaged members of the society who may be unemployed. Might be quite young and having very little passion for their teacher. Or maybe elderly and quite lonely and want to sort of feel connected to a community or a group of people. And so people could come to this centre, and they temporary live there in a hostel-style accommodation, where they would learn things like ...sublimely the responsibilities on how to keep up their welfare, and how to maintain a kitchen space. And then within that, there is... It's like a micro-society within this research laboratory. Because there are all these groups of people living... So I am trying to condense the scale of society into this research.

Frank: So you use the bee-hive...

Lewis: So bee-keeping introduces levels of responsibility, teaches about nature, science, and society in a way. How bees live there, these people live in a quite similar fashion.

Frank: Also these drawing have different scales, if I see that right.

Lewis: That's the other issue. That's why I think the tutors want you to work on drawing boards and nice pretty drawings, so you can work with scale. Scale doesn't really work in my case. [laughs] It's certainly an early stage. I don't know. We all develop our own scales when we are at a young age. And I feel like it should come as a natural ability to draw the scales. I just sort of sketch on this level. It sometimes kicks me in the butt. Cause I'll try and draw out the final design and I realise I've got a 5 meter tall wall and a 1 meter tall step. And I'll go "agh. OK, right." and I'll go back. But I mean I am really just second year, so I've got a lot to learn. But yeah, scale is one thing I am trying to introduce much earlier on in these projects. But yeah, it'll just be... Yeah, this design process doesn't, for me, fit out in an orderly fashion. They come in sort of bubbles, which burst. And so I'll have moments of having a complete design process from start to finish. I'll have an idea, I'll develop it, I finish it, and I'll pop it. That ones sitting on a long strand, if that makes sense. It doesn't sort of fit into that diagram.

It's loads of little design processes and then I gotta try and collect them into one... try to mould it or squish it into that sort of...

Frank: Is that a conscious process? Do you sit down and say: Now I want to mould everything into one process...

Lewis: No, it's not really conscious. It just happens, it just happens.

Frank: How do you know you arrive at a solution?

Lewis: It's when you sort of feel moderately comfortable with the design you might have come up with. I guess, that's when you need to put a cap on it. Or a deadline comes around the corner and you know you've got to tell yourself to finish. But I mean, this project. I will definitely revisit and redo entirely. But I mean, that's the good thing about having these deadlines. You can go... That sort of feeling of finishing a project is really good, cause it enables you to do a much stronger form of reflection than you can do when you are in the design process, because you are under this pressure to complete for that deadline. But being able to put a cap on it and then give yourself a week. And then you reflect and you say "I really liked that, actually that could be something, we could take it". That's a much more positive experience than the design process itself. So I guess, when it comes to the future, and I've got some projects, I'll set myself a deadline, maybe two weeks ahead? I know: I'll say this, but it'll never happen. But that would be the ideal situation if someone was informed that there was a deadline, but completely lied to them that this was the final deadline, but the real deadline was two weeks after.

Frank: If you draw out something, are there moments when you realise: Oh I didn't intent this to be something, but actually this happens to be quite interesting and you try to follow up on this?

Lewis: Yes, that always happens. That tends to happen, especially when you are doing abstract work. Where it is a lot more ambiguous and you can see things for other things and spin the paper upside down, and you see something else and that inspires you. And then, the idea that you are inspired by your own work and not just other people's buildings, other people's work, and art and stuff... is really, really interesting.

Frank: Talking about other people: How much does the group help you? Working in a group, is that something that works for you?

Lewis: Working in a group can or working with other people can work and can not work. It just depends who you are with. Sometimes it's good to have someone who challenges you. Someone that you think is on the same level and you can compete with them. Other times its nice to have a bit of re-assurance of someone who has a lot more knowledge than you and who likes to sort of beam that to you. It's nice to have that sort of backup. And then other times you can have people who you feel you need to carry along. It can be irritating but also quite positive because you can feel like… You learn through teaching is one thing, and it is also quite a nice feeling to help someone through…And […] always says: It's so much easier to talk about other people's ideas than your own. And the process of doing that can sometimes bring up ideas. Like yesterday, a lot of us in the studio were panicking, stressful, doing spatial layout. So someone might go and talk to someone else about theirs and trying to direct them towards your own. That just makes you feel good and brings up a lot of positive, creative thoughts. And when you go back to your own work, that really juices things up.

Frank: Does that also happen when you talk to people outside the studio?

Lewis: Yeah. That bee-keeping project… My mum is a bee-keeper. That's where the whole idea came from and I was able to get a lot of resources from her and research. It was just coming through a conversation. Rather than just sitting on a computer and search for this, search for that, it has a lot more character to it. Because you are getting a lot more ideas out of the way someone says it, not just…

Frank: I mean, you obviously know that she is bee-keeping but in other cases like: You go down the street and you hear someone talking and pick up something and use that later on. Does that ever happen?

Lewis: I can't think of a time it's happened to me, but it probably has. Yeah, overhearing conversations and stuff. Yeah, a lots of different types of research. Based on your prior research and just looking at other stuff, trying to narrow it down. But like I was saying at the start: That sort of experience of the environment at the site, that is a research in itself, which can almost not be recorded. Or can be, to a certain extend, but everyone here attempts it and then feels like they are justifying the real environment.

Frank: And totally switching topics again: You seem to be very sketch-centred? Your background is fine arts, you said?

Lewis: Yeah. I did a – there is just Arts in A-level. No, in GCE I studied Arts, or Arts and Design. Quite basic. And then I moved to Graphic communication, which was more Applied Arts, and Advertisement, or a book cover, or doing illustrations all the way through.

Frank: So what kind of material do you use in the process? Do you also use sketches, or do you also use computers, models, or what kind of things?

Lewis: Yeah, I use computers.

Frank: Writing?

Lewis: Writing certainly helps. I don't find myself that literate, I'm not that good with my words.

Frank: But I saw those diagrams, and those tree-things.

Lewis: Yeah, Bubble-Diagrams, and brain-storms, and that sort of things really helps to get ideas out. Sometimes recording your own voice. But yeah. I do a lot of sketching, trying to integrate computers where possible. But I certainly find there is a limit, sometimes with computers. A lot of people are getting straight onto google sketchup and then doing a render straight form that. It looks very plastic, very fake. A sketch can provide or can illustrate an environment a lot better than that, sometimes.

Frank: Why is that?

Lewis: I don't know. Because it has character and it has a sense it was done in situ. I don't know. I don't know. I don't know if there is any way of specifically picking up on this. I can get a lot more from someones sketch on site than if someone went on site, took photos and then modelled it in CAD. You get like a great sense of form, as opposed to CAD drawings or renders or anything like that. But I don't know.

Frank: That's probably missing the personal experience that you mentioned earlier which you have, when you go down to the site?

Lewis: Yeah, certainly.

Frank: When you are working on this project right now, are you already thinking about your next step? Or do you get inspired in your current work by previous work, or is each project totally separatedand you start over again, or sometimes do you revisit...?

Lewis: It's a bit of both. It really depends on the situation. Sometimes you think of... Sometimes you are in the moment where you reflect back on an old project and sometimes you are just completely looking the oposite way and trying to move forwards. It's really good, that's why it's really good to have these coversations. Because it can then influence me to then go back and look at an older project. And that's the good thing about the studio here at Plymouth. That you are able to sit within the same place in the studio, have your own desk. And then go to someone elses desk. It's rather than just feeling you are sitting down in a completely fresh environment every time you are going to do some study, or going to do some work. I now know. I have set myself set up a network of people, knowing that this person sat over there and that person is sat over there. So I might go over there to check on that person.

Frank: So do they have different roles in your project as well? You know that person is going to challenge you, that person is going to tell you something about, I don't know...

Lewis: Yeah, yeah. Yeah. To sort of locate them within the studio is quite helpful, it's good. It's very helpful to have these sort of conversations.

Frank: Thank you, that's pretty much it from my side.

1.6 Interview with Bailey Watson

Frank Loesche: Alright. So what I would like to know is, how you create?

Bailey Watson: OK, hmm... I don't know if you have any questions?

Frank: Sure. As far as I understand your whole process starts with a brief, is that correct?

Bailey: Not necessarily. The initial. I'll start… I'll do a timeline.

Frank: OK, that might be a good idea.

Bailey: So we start the, we get introduced to a site. Two years ago it was Exeter quay last year it was Union Street, this year it is Derry's Cross down in Plymouth.

Frank: I have actually been involved with the Exeter task, I talked with a few guys back then.

Bailey: So once we have the site it is down to us to analyse the site, find problems… We come up with problems basically. And from these problems we then create our own brief. So we, ahem… If there is a certain problem an individual wants to fix, then they create a proposition that would fix that problem.

Frank: How do you decide on a problem, if that's your first step?

Bailey: I am using problem as quite a vague word, it's… It's more of architectural problems. So if the road doesn't work, if the pavement doesn't work, if the building doesn't work. If an access doesn't work. Well, if an access does work, we identify the things that do work as well. We break them down. We ask ourselves why they work. Using our knowledge we have been taught, we can break certain aspects of a city down. From that, we then break the city down and then we take that forward. The distilled information. We take that forward into the problem that we found and we are trying to translate that into the problem to come to a solution.

Frank: OK. So do you already have a solution in mind when you come up with a problem?

Bailey: We are encouraged not to, but everyone does. When you get given a project you automatically thinking about what the end solution is. But they teach in such a way that we come up gradually rather than "I wanna do this at the end of the day". So when it comes to a project in, say I'll use the one I am doing right now as an example, so that'll be Derry's Cross.

And, originally I was gonna do like a market processing unit. It's now changed. After one tutorial it's gonna be a completely different project. So regarding the creativity side of it: The project changes constantly. So it's not like I am thinking about the end goal at the start.

Frank: In this example, what triggered you to change the whole project? What was the thing?

Bailey: It's the tutorial. So in a one-to-one with the tutor or even a one-to-one with a fellow course mate influences what you do. And they just bring in simple logic. Because sometimes you just sat in there in the studio for a few hours and you are not thinking straight and you are doing stupid stuff. And then someone just coming over. Even having a break, having a coffee, for example, helps. They tell us not to be in the studio for more than two hours, to get out, walk. Because some of our best decisions, mine included, are not in the studio. It's just when you are doing random stuff. Which is quite interesting.

Frank: Did you recognise any patterns in those random things?

Bailey: I have, I have! Ahem, I tend to come up with my best ideas before I go to bed. Because sometimes I read before I go to bed, sometimes I... ahem... For example I was looking at scheme in Barcelona, a fish market, breaking it down. And then I thought, wow! That would be good in what I do. And then it comes back to the idea, of I broke up that building into simple why and why it doesn't work. And then pull it back to my scheme and thought, OK: This bit doesn't work, I can make it more like this? Of course, the setting is different. And then, yeah. The process just progressively gets harder and harder and then stopped. We go into more details. So it's not just the box and we are trying to position things within the box. How people walk into this box and things like that. Then it goes down to experience.

Frank: So is it always this process of starting at 10,000 foot and going down?

Bailey: Yeah, yeah. Well, we are encouraged to... Say we work at a scale of 1 to 1000 we then go to 1 to 100, then they tell us to go back out again, and then go back in — and that's the process.

Frank: Does that work for you?

Bailey: I love it! That’s how I work. So when I do it my way, I initially do some sketches. And then draw some more detailed plans, and then model that so I can see it in 3D, so I can hold it in my hands and look at it.

Frank: So you build real models or rather computer models?

Bailey: Both, really. Both simultaneously. Physically it’s easier, because you can take a close look at it and stuff. So I build a model, like an A4 model, look around it. Then they tell us to section the model to see the space inside. Then, to go back to the drawing, draw problems, and draw another plan, and model that again. Now you have two models. Compare them. Go through that another 15 times or something. So that’s how I progress, anyway. And it’s all about the experience of the person. So we are taught to design for people, then for a place, then for a building. That’s our process. And sometimes, I was thinking about this the other night, in Architecture we happen to think about the happy accident. I don’t know if you’ve... So when we do... It doesn’t happen when we are drawing, it only happens when we are modelling. So if I was modelling a building and accidentally put a piece of cardboard in the wrong place, and then look at it and think: Wow. That’s actually what I did. And that, then, gives you almost like Adrenalin, and you think wow, and then you just get so involved in it. And then, take that back to drawing, model that again. That little cardboard can change your whole scheme.

Frank: So does it also depend on the type of model? So if you have a cardboard model and you accidentally drop a piece of glass on it.

Bailey: Exactly! That happens a lot! People’s models get dropped in the studio and there will be a mess on the floor but they take a look at it and go: Wow, that’s incredible.

Frank: But you don’t drop your models on purpose then?

Bailey: No, I wouldn’t do that.

Frank: That couldn’t be part of the process?

Bailey: Some people probably have, maybe. I don't know. Personally, for me, the are to precious to drop. But from personal experience, dropping a model and looking at it, that has happened in the past. That process just keep going and coming, really.

Frank: Why do you think those happy accidents work? How can they trigger something you haven't seen before?

Bailey: I think it's more of a... I don't know. If it happens, you look at it and think, why haven't I thought of that? Because we get so involved in a certain thing. Like I said earlier, it takes a bit of an outsiders perspective to look at it and say: oh, what about this? Then, it's a completely different thought process then. An then you frame your enquiries completely different. I don't know why it's like this. It's just oh: I'm so involved in this one part, but changing that one part changes the whole thing as a whole. Maybe it's nice to get someone or that accident to happen, to talk to you, and tell you that if you move that there, it changes this...

Frank: So do you talk with your non-Architect friends and family members about your work as well?

Bailey: Yeah. I live with my girlfriend. She does medicine. So she has no clue what I am doing. And all the time... Another thing we get told in Architecture, when we do our final presentations: If a member of the public could walk in and see the work, they should instantly know that it's about. If they can't do that, then the work doesn't work. So I use my girlfriend as a...

Frank: proxy?

Bailey: Yeah, yeah. So before a review I show my work to her and I go: What is it? She might know bits of it because I talked to her before. If she says that could be that, that could be this, then I know this will get me some extra marks. And it does! So having my girlfriend talk to me about this...She has no clue about Architecture, though... So this building I am doing at the moment — no clue. But I'll ask her about a certain part and she'll go: I don't really like that. And I say: Why? And then she tell me and I go wow. I didn't really think of that. Because we are taught in such a way, that we are Architecture students, not public. So if we go into a building, we are already reading the building as it is. When we go to an Art museum, for example we went to one in Copenhagen, none of us were looking at the art. All of us were looking at the building. But the part is, the art is within the building, it makes the building what it is, which is what the public sees. We were like: the door is there, the window there, there is glass there… And they were telling us: look! We were a load of Architecture students — but don't be a load of Architecture students. Be a member of the public. And it changed my experience of the place. And doing that, they teach us some sort of exercise, that almost disconnect us from the studio, from the architectural world, take off the architectural hat.

Frank: So how does that work. How do you do these exercises?

Bailey: It's hard. They tell us, when we do the analysis of the site. For example when we do the Deryls cross, they tell us just walk down there, just experience the site. you know, it's hard for us to do, because we are like… We are looking constantly, there is a building, and building, and building. But they try. But it's hard to disconnect. But it is sometimes easy just to walk down there, walk through there, and walk home, and then take notes of what has happened. Don't take a camera, that's one of the things they tell us, don't … And draw it all from the mind, from memory. Because then you pick up on certain things regarding the site, you are not just tracing over. Yeah, that's how…

Frank: So how often do you revisit the site during the process? Is that something you only do at the beginning to get an inspiration?

Bailey: We… I visit the site… I work down there, so I visit the site three times a week. Well, so not visit. I go through. So I'm a different user.

Frank: But for example for Exeter, you might not have walked through there so often?

Bailey: Yeah, Exeter… Maybe once a month. Well, the project lasted for the whole year, the whole ten months. So every three months. If we were doing a big project, we would do the project. We would then go… right OK. Because the project is in isolation and it's not actually there, we have to go back to the site… OK, putting it there doesn't really work, so we move it there. The we come back to the studio, re-evaluate… It's hard to design a building if you are not really there. It lacks experience. You don't know who uses it. And that's one thing, we are taught in Design. It all comes down to the process.

Frank: You talk a lot about we. How do you work in group, or what role does a group have in your work?

Bailey: So, commonly within Plymouth, the second and third years join together which is rare. That doesn't happen in many places in the UK. And I think it's quite interesting. Because I have seen Architecture schools isolating second and third years, because there is such a massive drop between first, second, and third years in knowledge. Here they merge together, to refresh the third years, because we are so involved in our dissertations and things going on. But also for us to teach the second years as well. So we get put into groups of four or five, two second years, two third years. So we get to choose a site, create a master plan within our site to design the whole of our site. And then within our site we position our buildings. But then these buildings need to link together regarding the propositions and occupations that inhabit them. So we are in constant dialog with the group. As well as the year as well. They like us to talk with other groups. And use their propositions in our proposition. Sam, I am linking to him even though he is not in my group. They really like the team bonding aspect. And sometimes it really does help to have a team, but sometimes it doesn't.

Frank: Why does it not help?

Bailey: This course is very demanding, and some people, they almost lock themselves in. They are just concerned where their building is going. And it's hard to communicate with someone who is so isolated. And that almost weakens the master plan. Because there is that isolated building on the side, that noone is connected to. And that's frustrating, because we need the masterplan to work as a scheme, and when someone is not following it.

Frank: How do you work with these people? Do you try to challenge them, do you try to be authorative?

Bailey: I had it a few times. My personality is... Because I already work in an Architectural office, I know how it would work if we are outside the university as well as inside... The group I am current in, I am struggling with one student. He is not doing as much work as he could be doing, and it's slowing us all down. Because I am trying to get the group work done first. So I can then go on to my individual work. So I am trying to get them to do certain work, because they are not doing that at the moment, and that's hard, very hard.

Frank: So you are trying to take the role as a group leader, weighting in all your experience as a third year student and your real life experience?

Bailey: Yeah, that's how the second and third years see that in hierarchy. So there are two third years, who are like the leaders. And then there are the second years, who look at us and we teach them, and stuff like that. So when a third year stops to, almost pause, it really slows progression down. It does affect my work as well, because I can't exactly do that part of my project, because I need him to do this part of the project. But, there are things put in place to help the people who are doing the work, and help the people who are not doing the work. Lets see for example the tutor. He would step in and intervene if something was getting out of hand.

Frank: So he would see that, or would he need your hint?

Bailey: Both. The project I had last years was five of us and four didn't do any work. But that time they put us in groups, this year we got to choose our groups. Which is good and bad. And last year I told him, but he also knew, he could also see this was tough. He helped me on that regard, which was nice because I knew in the back of my mind, that I would get a pull down from my group, which was a relief. And he does that quite a lot.

Frank: OK, so what are the positive aspects about groups then?

Bailey: So I was in a group in Exeter and I never had so much fun in my life. If you get into the right group, and everyone works together, and it works like a well oiled machine, it's fantastic. The energy within the group, and the projects themselves. And even the tutors can see that they work. That's it, there is no other way to say it: The projects work. It's amazing. It's fantastic. Because... I wasn't worrying that X and Y wasn't doing their work. And they were worried I was still working. We were all on the same page, every few days we were having a meeting and we'd say: Look, that's where we are, this is where we are going, this is where we need to be. A few days later we'd come back and say, this is what I've done, this is what I need to do...Constant conversation between each other. That! I got a good mark for that. We all did. We all got a very good mark for that, really. It was fantastic.

Frank: And was that project difficult for you?

Bailey: Which one?

Frank: The one where you had the good experience.

Bailey: I would say no, it wasn't difficult because we were all working together. It wasn't like I am struggling to get this information out of somebody. The information was already there for me to grab. We didn't have to ask questions. We already knew the answers. I could progress my building constantly, while the other were progressing theirs. And that was really good. But regarding the project now and last year, where I didn't have the good group, it's hard on me. Because I know, that's what I want and it should be happening, but it's not. So I am looking at that project thinking, that's where I wanna be, but this is where I am right now. And it's not really much I can do about it. So I put more stress on my group, or not stress, but... hardness on my group. So like: look, I wanna be like my group before because I just want all of us working together.

Frank: Did you try to implement some of the group interactions that you might have had back then?

Bailey: Yeah, yeah. Exactly. I'd schedule meetings every Wednesday where would come in and have meetings. And regarding exercises, like drawing or talking. I'd set up a room, just for us. But its... It's struggling for me, because it's not working how it was before. And because I did so well in that project, I wanna do well in this project, my final project. It's not much I can do about it. I am accepting it that they will not be like the group before. So I almost have to change my way of working now. Because at the end of the year, we all have to present our buildings at the same time. And if they don't work, or if they don't work together, then the tutors will bring it up and we will all get marked down. Regarding the mark, we get group marks and individual marks. They have different weightings. And the tutor has influence on that, which is good.

Frank: I am pretty much through with my questions. Thank you for your time.

1.7 Interview with Charles White

Frank Loesche: So what I would like to learn from you is: How do you create? If asked you that question, how would you respond? Or should I rather ask you more specific questions?

Charles White: I can start with that. It's not a clear process, I would definitely say, it's actually quite nasty. I am definitely a culprit of thinking quite a long time. And then... Interestingly, the panic of the deadline looming then forces me to produce quite quickly. So I think I work quite well I'm being pushed into a corner. But I have done quite a lot of thinking before that, so that thinking then comes into play. I am personally trying to work on thinking and doing more from intended, earlier on. I reckon that's probably better for me.

Frank: So when is the sweet spot for you? When do you start doing?

Charles: A week before the deadline normally [laughs]. But this time it's actually happening a bit earlier, which is good, there is more time to work on. So I kind of force myself to do more stuff with my hands. That, in turn, is then probably more fruitful that way. Because normally I am afraid of going wrong. So I am spending a long time thinking about it. Because if I am not bringing it down to paper, I am not making a mistake. An I go through a lot of things in my head, and normally it works out right. So I am now trying to make it more of a multi... Basically trying to combine working and producing to go more hand in hand now. Yeah, beforehand I think it was really going into that corner, that helps.

Frank: So when you start producing, you already have a very clear understanding of what you want to do at the end?

Charles: Yeah.

Frank: So you have already processed every possible outcome before, and then you just put it into existence, out of your thought?

Charles: I try. The thinking is also... I am not producing output in the University and academic sense, but a lot of thinking comes hand in hand with sketching — which I should have mentioned. Yeah, so lots of scribbling.

Frank: OK, so maybe let's go back to the beginning again. So when you get a new project, does the tutor come into the room, tells you "this is your site, you have two months" — or how does it work?

Charles: He says, yeah... you have about two months, or one and a half. This time they have given us the whole brief, which is interesting. Sometimes they drip-feed us because often, when people have the full brief, they jump too quickly. So they drip-feed us, to give us just the right amount to do. This time, the tutor has given us just everything. So he has given us the outcomes that he needs. So it's slightly different. Now that he has done that, I just start analysing the site.

Frank: How do you do that?

Charles: Lots of visits. Researching the programmes on the site. Trying to work out what the gap is, what could be useful there. And what would kind of enrich the site, because its quite a... ...sits not a particularly high... Its a place that is kinda falling to disrepair. So we are trying to think, what can we do. Although we are doing a master plan on things we can change on a large scale, at the end of the day we have one project. What is that, how can do that as much as... That's what we are looking at. So trying to look for gaps, look for spaces. Trying to work out the atmosphere what it's like to be in the site, and what's the atmosphere we want to create? And how do we go about doing that? That's how we are trying to picture ourselves. I suppose as a group we are trying to produce outputs that are trying to capture that atmosphere, and then the atmosphere we are trying to create. So we are trying to create those walled gardens, those intimate spaces. Where as Plymouth is very linear and sparse, it's almost kind of like Wild West. It's quite low and having those wide streets. And all the buildings have kind of like this false front that looks quite grand, and it just crumbles away at the back. So we are dealing with that crumble bit. And trying to kind of… Instead of it always being oriented towards the street, there are all these courtyards or car parks. And we wanna try to flip the orientation two ways. So we are dealing with these car parks that we want to make into courtyards or more intimate spaces. So we are trying to make walled gardens, these little gem-like space, which hopefully start renewing it. So that's kind of our thought.

Frank: How did you come up with that idea?

Charles: We spent a lot of time looking at the site.

Frank: As a group?

Charles: As a group and individually, and I think we all got this kind of critique of Plymouth of being too large and too sparse. And maybe these places, these localised, centralised spaces are necessary. We started coming up with it… One building, for example, is a… Sports Direct. It's one building that we had. It's like this: It's a solid building and there is more shops in here. And then we traced it inverted to create a walled garden. So that was kind of like an Aha moment. I mean, I call this a walled garden. This is kind of the heart space for our site. So that's one thing we are working with. And then its just kind of playing with that: How much openings do we want? Do you want to have this kind of surprise when you go inside? Do you want to open it up, so that people can see in completely? Do we want to conceal it to some extend? We still want people to know they are welcome when they want to go in, but we don' t want them to be able to see everything that's in there. So it's kind of working on where is that balance? My site is here. I am creating a music school. A kind of community school, where small groups can come. So it's kind of the soundtrack to this garden. On the one hand I am now playing with another balance. We do want people to know of its existence and hear the music so maybe they can interact with it. Maybe that motivates them to go to that school and pick up an instrument. And on the other hand we got the people that need to practice and how exposed do they want to feel. So I kind of place the band spaces and the group spaces on the bottom. And then some more spaces up high. So that's kind of, a lot of what I do is thinking about balances. So on one hand I wanna do this, on the other hand this, and where is the point where they meet? So that's... this is more... when I am... this book is... I am kind of starting to understand things, but there are still questions. Whereas this book is more... This is... I'll document a lecture in here, but at the same time I am also scribbling stuff and working on stuff.

Frank: So you first work in this one, then you select elements and move them to the other one?

Charles: I mean it depends. If I am feeling fairly focused, I can go straight to this one. But for this one I don't worry about it being pretty.

Frank: How do you know when to choose which book?

Charles: This one I... Cause sometimes during lecture something comes up, not necessarily related to the lectures. So I am scribbling there. This one is more a document of my process. And my tutor might look at this. So this one is more outwards orientated as well as being used for myself. This is pure me. So that's how that works. So it's kind of starting to become a bit more messy and I am working stuff out. Whereas before, when I first started, once I worked on something I put it in. Where this is more work in progress.

Frank: I see a lot of different scales, and different perspectives here...

Charles: I think they always told us: don't confine yourself to one scale. You might spend ages working on a scale and then you switch scales, and then it causes problems. For example, I was working quite a long time on 1 to 500, but with that, and I don't know what it is, you tend to end up with spaces that are too big. Because it's quite hard to understand the human scale in relationship to that scale. If you draw a section in 1 to 500 and you draw in your humans, it's quite hard to get them right, because it's just too small. But you start getting an understanding at 1 to 200. You can then just get him big enough, relate him to... Yeah, so working at different scales, there are different merits at different scales.

Frank: How do you know when to switch between those different scales?

Charles: Normally it starts off big. So 1 to 1000. Then it kind of goes down smaller. Once you get... At the moment I am trying to work at 1 to 500 mainly, but I keep looking and switching to 1 to 200. But it's not just the scale. I think the key thing is to work at plans and cross sections at the same time. Here I am working in plan, but I am working in section here. And here is a section, but I immediately put it on plan. So that's how I have been working on here on my page. So its about switching scales until you have sections and plan working at the same time. This is how I am dissolving the task in my thinking stages. I kind of passing through all my thinking stages. I am not yet creating my photo shot outputs that end up pretty and go on the board. So I still think this is kind of the thinking time, even though it is visual. Kind of thinking what you can see from where. Things like that. So whereas before I was in the pressure that made me create something, now I almost put the pressure on myself.

Frank: So how does this work in relation to the group you are working in. Is the group putting pressure on you, are you putting pressure on the group?

Charles: Yeah, actually. Because they are all good workers which is good for me. As I said, I work hard. If I am working by myself I might be a bit more relaxed. So I think working in the group is good for me. Also working with second and third years, I am a second year, definitely helps.

Frank: Do you also take input from them? So if you see them bringing something, do you take and develop it? Does that inspire you in some way?

Charles: Yeah it does, yeah. I mean, we are encouraged to bounce off our ideas. There is definitely a... everyone is always a bit funny about their own ideas. And its always like: Well, I gave you that idea and you gave me this. Oh, but you never said... Which is definitely something we need to reduce. I mean, I am always a co-worker who is trying to re-invent the wheel. I want it to be new. I want it to be never done before. I think if that is your aspiration, that will never happen. So I keep holding my answers and just keep waiting and waiting and waiting. But I never re-invent the wheel [laughs]. Yeah, so there is this slight thing about ideas. But as a group we are pretty good because we are all working on the same side and we all have the same master plan to work on.

Frank: Do you also go out and try to get inspiration from other gardening places?

Charles: Yeah! I like reading, weather its novels or... I quite like reading Philosophy. I like to take inspiration from things that are written. From an Architects point of view that is much more subjective than if I looked up some buildings on Pinterest. Because if I am on Pinterest, it's very hard not to see that shape or space they are trying to be creating. Whereas if it is in a different medium entirely, I can get inspired by it. And the way I read it and make it into an Architectural way would be very different from someone else making it into an Architectural way. So by choosing a different medium, a different genre, it allows me to be inspired and I kind of get the inspiration that I need without falling into the trap of copying.

Frank: Do you consciously use that for yourself as well? I saw that you write about your work?

Charles: Yeah. I mean, I like writing. I just wrote some essays. So a lot of that is just me interrogating how people will respond to the building and how much does architecture articulate the space. An entirely flexible space doesn't necessarily let the people appropriating it, using it the way they want. Actually, if you create a certain set of parameters, people are actually more inventive in their response to them. So that was something I was looking at through writing.

Frank: So do you think, if the tutor came in with a very constrained task, would you be more creative? Or is there also a balance between that?

Charles: I think so. I mean, we are told to think about a program for a space. I find that very hard, because it is a very open question. And I don't want it to be a box-ticking exercise either. I want to be able to respond in an effective way. So it needs to have some parameters to respond to, so I can be inventive. I mean, with the same version of... When I was talking about this same version here. It is much easier keep this and play with it, as you can see the emerging designs here... I can be far more... I can probably produce something far more interesting, far more inventive, when I play with something that's already there, than if you gave me a blank field. I mean just designed in a blank field and won a competition, but it's still nice to have these parameters, whether or not they are physical parameters or a brief to play with. Because if it is too open…

Frank: So in this case, the blank field, you came up with the constraints yourself…

Charles: Yeah, so we used it.

Frank: So is that a technique that works for you?

Charles: I think so.

Charles: Yeah, I like that.

Frank: Is there any other key element? This inversion seems to play a vital part, but is there another key… At some point you came up with the emphasis of sound, the music school. How did you choose to get the music school there?

Charles: We all wanted a program that would enrich the site. I was one of the later ones thinking about programming in my group. So Matt was doing a workshop, some kind of community workshop where people can come and build their own things. It's a bit like there is a University, but for the community and for everyone to come in. Jackie was doing a similar thing, but on a smaller scale, doing a jewellery workshop where people would come and learn. It's all about facilitating the community to learn. It was all about enriching the site. With me, I also sort of wanted to encourage an individual to enrich their lives in variant different ways. Whether or not its a luxury like music or a workshop, they actually need a prop for their business. I like music one. We also had this walled garden. Part of it was stemmed out of, how do we get people into here? We are all making these things here, and maybe there is an acoustic quality that draws them in. So I started to figure out a soundtrack to the site and we also use the existing structure that we wanted to keep, like in a church-like quality. Churches are both, kind of quiet but there is also charged with sound. I thought if there is some kind of performance, like a musical, I thought that might be useful. So I started playing with the music school idea. And then just thinking about the acoustic qualities of that, really. Here I am playing with audio and visual, maybe there is also kind of a journey through. Here is a diagram of this. One of the entries is through and existing shop, which I am turning into a mimicry shop. So you are going into the shop and it suddenly opens up. You wouldn't know it was there, you were just going into a shop and it suddenly opens up into this large space. This is the shop. So you are going into the shop and it opens up. And then maybe they can see people performing or practising. So I kind of wanted this journey of going through. Maybe it starts auditory and then you go and see. Or maybe you can see it from the distance, and then you need to go around and you can only hear it. And then you go and listen. I am kind of playing with those ideas, what draws people to the spaces. If I can hear something, I probably want to be able to see it, and if I see something, I probably want to be able to see and hear it. Either way, the journey starts when you move in. That's when I thought about the music school.

Frank: Great. But that's very abstract, at the moment for me these are just lines. Do you already have some kind of image what it will look like? Are these concrete walls, is it wooden?

Charles: These are existing brick walls of the existing building. So I got that to play with, I got one material. I have the acoustics to think about. So these will be fairly soft materials. I have a loose, a very loose idea of it in my head. Very loose. I have a very loose idea or maybe I can picture just a small amount of it.

Frank: So how are you going to catch that idea at the end?

Charles: That will be through drawings. That's when I start comprehending what's happening there, and what's happening there...Otherwise it's just a shadow in your head. I don't know what it is, yet.

Frank: Do you use other media, like computer modelling?

Charles: It will get to the point where I will get onto the computer.

Frank: But it's not something you are using at the moment?

Charles: I am making models, I am making physical models at this time scale. I printed out some... I made some plans, but it's more like boxes. Very sketchy. So I photocopy that, put it on some thin card, and then just slice it up and just stack it in the areas. That gives me certain areas. That's a very quick way. That's one of the things I have done. That's when I feel like being more productive early on. It really helps working with that medium. I use words quite often, because I am good at describing things. Because through reviews I can understand what you are trying to achieve early on, without doing a physical drawing. It means I am trying to hold off the outputs for quite a long time, which isn't a good thing. I need to do outputs early on.

Frank: You said earlier on, that you are afraid of mistakes? So if something goes wrong with your model, do you just throw it away?

Charles: No, I keep it. That's the type I tend to keep in here. I am kind of OK with making mistakes in here, I am now starting to be OK with making mistakes in here as well. But even for the model I just made, that's OK. Because there are a few things I will change. But yeah, that used to be a problem.

Frank: As what kind of Architect do you picture yourself in a certain time, let's say in five years from now?

Charles: I want to be successful as an Architect. If that's the case, then you get to design... you get more flexibility to design. I want to be successful because that means you get to design your own buildings.

Frank: Do you specialise, or think about a certain type of Architecture that you want to do?

Charles: I like the small domestic scale. When I started... when I wanted to be an Architect when I was younger. Well, when I was 18. I wanted to be a dentist, but I changed... I always wanted to design my own house. Once I started studying I also saw the larger buildings like museums, galleries. And that's also interesting. It's quite useful to do this interview.

Frank: Thank you. Can I ask you to fill in one more form?

1.8 Interview with Zak Walker

Frank: I would like to learn how you create. If that is too general, I could also ask in more detail. But maybe you could start with a quick summary of how you create?

Zak: So I think for me, something really... In my second year, I found it kind of hard to create without kind of doing it step by step with a brief that we were given. And then last summer, when I was finishing off work for the year, something really began to click with me, I suppose. And it was about the tutor giving clarity to a sketch, or a diagram... OK, so it might be an item from the brief that I would take and make something from it. I would then be given feedback, like I said. And the tutor would then start to step back from "This is your next task". And this kind of instilled confidence in me. So if this was a diagram we were doing to explain the spatial arrangement then it would go from that. And they would maybe give a prompt, but not a solution. And then I would sort of begin to grasp where it might go in terms of the next thing to generate what it is I am trying to get to, if that makes sense? For instance from that diagram I was looking at massing models. And actually choosing objects, solid objects, that only represented something in terms of mass, not height, width, length, detail or anything. And just manipulate those shapes. I said to myself, just produce a number of outputs, six seemed to be an obvious solution for some reason, take those, document those. So that there is a series of steps or evolutions between those things in the order they are actually produced. Take the sixth one and say, I kind of got to this. Now, how do I translate this into something, I guess, how to refine it slightly? So I take that model that wasn't of any particular scale. It just represented some scale of importance or anything like that in terms of its size. And then try to apply some parameters to that. So maybe create a spatial model of 1 to 200. Those parameters are then so fixed in term of how thick a wall is, how big is an opening. So then I actually start to put the scale of a human into that sort of spatial setting. And from that I began to... By going from that one initial step where I had some feedback to then generate something on my own as a kind of way to refine that. I took that a step further by making this model. So I began to kind of let go a little bit by the tutor or by that sort of thing. And began to kind of steer the project myself a little bit. And as that kind of went on, the task I was undertaking, or willing to test, or try out, became much more rapid.... Work began to generate it faster. Because it was about going through these processes and not finalising something each stage. But maybe more of a: OK, just get a little bit of an idea, this is starting to work, take a spatial model. It was then about bringing that up to a different scale like a 1 to 100, for example. And actually to begin think about how will that space, and I know we need that space, because it has to provide a function to this overall programme. But what equipment needs to go into that space to actually provide its function? And a 1 to 100 scale allowed me to do that. I put in equipment, I put in a human scale. Back to the free plan. OK, so in the free plan this is working, but in structuring a level situation, how does this work? So it's about taking that plan, that wasn't very refined, it wasn't about taking out a scale ruler and then precisely drawing the line and making sure the pencil line was the same all the way along. But rather I'd roughly sketch it, mark a couple of points for length, fill it in by hand. Take that plan. Do the same for a section. Draw some markers, draw a section, draw some indicated height of things that might be existing. And then I was saying, I got these ground sections quickly sketched, what if I bring that out into the model? So I actually begin to model that. Which allowed me a platform in which to photograph. Which I could then collage perspective images out, which would then give me a spatial quality for those individual spaces. And from that, the process began to become a bit more iterative, again.

Frank: So what would you do next?

Zak: So from taking the perspective images, I would kind of put it on the back burner. So I was thinking, this space is setting up something, but I then need to think about... I will come back to this once I worked out how the spatial arrangement actually might be, in order to some light qualities perhaps, surreality qualities, those sorts of things. Or maybe detailing.

Frank: Do you have an order of other qualities that you try to look at afterwards? Do you first look at the space, then light, then function?

Zak: I think for me it went from...

Frank: How do you decide what to tackle next?

Zak: I think what I do is I went back to my plan. Because in my mind I have that idea of producing several versions. Then jumping to a different medium to test out what I produced. That actually meant coming back to the sketch. Sketch a section. Taking a sketch section, printing it out. And using it in 2 1/2 dimensions, so choosing a 10mm build-out section to kind of draw around some of those kind of elements as it were. Floor line or roof line or wall here or opening there. And just apply some physical elements to those sketches in order to realise those qualities. I didn't do that with the plan, even though I could have done that with the plan. For what I went to do from there was to say: well, OK. This actually gives me a stepping stone to produce a sketch model of this. Work out... OK, so the sketch model. Photograph it. Print it out. What's wrong with the sketch model? Why is it not working perspectively? Why is it not working in a plan view? Sketch over the top. Take those iterations. Produce another plan, rough sketch, sections... Model again, very quickly, just to clarify those elements. 1 to 200 scale again. And I went through, I think, 2 or 3 of those models. Sectional, 2 1/2 dimension models I made three of those. And there I fracture it with three key sort of spaces, to try and... Because, from working out key spaces the other become kind of auxiliary sort of spaces, that's important. And then from there, I began to say OK. There has been a number of iterations. I've got all this information to support where I have come to. And then it became about, due to time constraints actually then, what is a final plan section, but not finished? So it was kind of a place to pause for assessment. It was a sort of a finalised image. And so, from going through that. And having feedback in terms of written feedback, grading, those sort of processes I went through allowed me to say, I'll keep it for this year, the third year. I can forego that sort of tutorial support in a sense, and actually apply those processes I did last year in my work this year. Although, where I was producing those kind of outputs in the summer was... Actually occurred later during the design process. So how to think about this year, where I begin a new design process from the beginning. What do I need to embody into myself to allow me to get to, when I was at that stage... When I get to that stage this year, I am ready to apply the same kind of techniques. So I think what it did ultimately just let me to...Because we were given a bit of a guidance in terms of initial briefing for this year... So actually... So that might be existing context, plans, sections... Actually I was able to do those kind of task more quickly this year. I was able to think about work not being seemingly complete. But actually were able to distil some of the things that were required of us. And didn't so much require things like plans and sections. Because of the nature of initialising the projects, but sort of going from that initialisation to where we are now. I have began to think about my spatial programme. I have began to think about bubble diagram. Being something that's very iterative, very quick. And taking a point where its... This is at a point where it's undergone a certain level of development. It may or not be right, but I feel confident that I can translate this and test it through another medium. So I used bubble diagrams this year. Started to produce massing models. But I felt I could mass by hand or use a digital technique such as a 3D printer. Which is what I did because it saved me time. For the same volumetric output that I would have done by hand. And definitely accuracy was more on my side.

Frank: So does the accuracy help you? Or is the roughness of a hand-made model something that might support your creative process as well?

Zak: By doing that task, it gave me more time to arrange the spaces. I got to, I think, this time six iterations seemed quite comfortable again because I had the time on my side. So I took that model and I decided, what I would do is, I would just simply photograph. I photographed all of them, in case I ever had to fall back on a particular step. I took the sixth one, photographed it, printed it out. No, sorry. I photographed it. I scaled it up - roughly, because I knew the model was produced 1 to 500. And at that scale it allowed me to be more free without a lot of spatial constraints. So I scaled it up to roughly 1 to 200, which allowed me to roughly sketch over a plan or spatial arrangement. And how those space might actually interconnect. And from that again I would do a section, very quickly. Printed off the section. Would add a 2 1/2 dimension to it. Which allowed to then decipher where the ceiling height might be, where the ground height might be. Where is the relationship of those spaces in section and their roof or floor heights to another adjacent sort of space. And so from that I was able to. What did I do then? I took that and I began to produce a

1 to 200... somewhere between a massing model and an actual model. But it's a model that's essentially is a massing, represented at a different scale . But it's allowing me to input human scale into that model. It's allowing me to test...

Frank: Why can you only do that on a 1 to 200, not on a 1 to 500? Is it too small?

Zak: The 1 to 500 doesn't allow you to kind of put yourself in a first person humanistic scale into the model. 1 to 200 begins to do that a little bit. Other scales would be better, 1 to 100, 1 to 50, 1 to 20... But they would require too much in terms of their detailing, yeah, of their detailing or their condition to actually be able to go that far ahead in the initial stage.

Frank: So I guess the current project doesn't require you to go too much into detail then? At the end of the project you might just present a rough idea what the Derry's cross might look like?

Zak: Yeah, I think so. I think the project will eventually allow you to refine it. Work schematically though it and begin to refine the project, you can begin to elaborate on those special things. Larger scales apply a material element to it, apply an experiential element to it.

Frank: How would you apply those material elements to it, for example?

Zak: Initially, I suppose, you could take what might be a rough section, 1 to 200. And increase that to 1 to 50, perhaps. You could then apply physical real world elements that you can find or manipulate. You could apply that to the model. Or the alternative could be, to photograph it. Put that model into a programme, like Photoshopping programme, and apply textural elements that might give you those sorts of conditions. It might be that you could work with pencil or some other tool into that to actually, through shading, to draw out maybe experiential qualities, such as lights, that sort of things. And then I think from that. Because you've began to, let's say. I've got these material elements that will allow these quality structures like experiences or the way it feels... You can bring that to a much larger scale, 1 to 20, 1 to 10, 1 to 5. And you can start to say, in order to construct these material elements, they need to be detailed in this way. Which means that the construct will go together by way of just detailing. So from doing it beforehand in card and doing a lot of it by hand versus 3d printer. I think when I did it by hand in card, as I was putting together the card massing models previously, I was, I think I was more aware of my hands, even if the scale wasn't allowing me to represent the spatial intentions. It was allowing me more to think about those spatial relationships as I was doing it. So I think what I am trying to say is, when I was trying to do the 1 to 500, I was already conscious where I was going next and maybe the next scale, than I was when I said OK, produce those spatial relationships, send them to the 3D printer, because the 3D printer was just producing it. My mind was actually elsewhere, thinking about something else. So what I might have done was actually taking me off the tangible. It might have made me less prescriptive to the design process, possibly. I know that my mind was neutral in terms of the spatial arrangements, cause all I would be waiting to do is for those models to be printed and then to arrange them. Which is kind of, seems a bit of contradictory. If I wasn't thinking about the model being produced itself, actually my mind was free and I could have been thinking about spatial arrangements, but I wasn't. I was thinking about other aspects of the outputs and that sort of thing. So I actually think in hindsight, the manual massing, that sort of thing, would have lend itself. Although it didn't allow for more time, it was more intuitive in a sense that it was already.... Because I had to think about... So that was what would give me that drive in "What's the spatial arrangement?" I know, I'm not doing it, but when I come to do it, what it's gonna be? Which would then allow me to jump, I think more smoothly, into another scale, if that makes sense. And I think probably, by, cause I initially had a tendency to do a section and plan on AutoCAD, or do it on computer because I felt it would be a bit quicker. By looming to me through kind of Lumière shapes and things, what it was actually doing was kind of the same as the 3D printed massing models. It wasn't getting me to think about so much the next stage. Because all I was thinking about was completing that drawing. But actually there is never really an end to it, because you can keep chopping and changing it, just drawing another line. Actually, by doing something by hand, would have done this time for plans and sections, through doing that, it allows me to think about the next scale. So, the digital tools, although initially could be quicker, to realise something, actually I think are hindering us, in a sense. Because, like I said, by doing it by hand, you are actually driving that tool, which is, you know, you are trying to bring out something. But you haven't to think about other things, you haven't to think about spatial parameters. So you are already in the next step ahead, while you are doing it in the previous... So that's kind of, I suppose, where I am at.

Frank: Does it ever happen, that if you do a manual model, or if you do something on the computer, something accidentally happens?

Zak: If I find... Because I think even by drawing out manually these quick sectional things, you feel actually you might be a bit restricted. So you pick up the sketch book. And you can just scribble something. And before you have even scribbled or you thought, it's gonna be part of an image. You have already realised something. And you just want to get the next piece of tracing paper over the section or plan you have done. It's not even finished. It's not even finished. You have not annotated it. Not even put a door in, or a window. You want to pause that there, you want to get another thing. Take the thing that you just sketched. Take that out. Work that over the top. You feel like what you end up doing is bridging the thing you been drawing before and the thing you have just drawn. And you got something other. OK wait, I am at a point now. I am at a point where I should now develop this several other times. Or should I test it. Should I model it. And it's those moments where I think I actually struggle. Because its like, that you need to be intuitive in order to meet the demands of the brief, you know that you've got learning outcomes, you know that you are gonna be graded, you know that you gonna be looked at through several things. And, you've produced... So you started a drawing that has evolved. You produced one rough sketch and you decided this is the point where I jump. What is the correct thing to do? Is it to... Is it to now... Take this drawing a number of times and redraw it before you actually test it...But I think generally, on the whole, I would... Yeah, I think what I would try to do, is to look at... Take what I was drawing, take the other half drawing, combine it, make that into a single entity. Then I would say: This, that thing that I sketched, has gave me... it is not replaced what I was doing, but it given me a part of the solution where I was struggling. So actually, it's not something other. It's just the thing I would have drawn had I been able to keep going and known what it was I was going to do. So I take that thing, that I combined. Produce probably a number of iterations. I like this thing of working in threes and sixes. That seems to suite well with me. It seems to show that I've... I've thought about a number of combinations. So I probably would work that up a number of times. And then I would take it into a model. That would allow me to test physically. I wouldn't be going back to computer I don't think, to kind of to do that. Because it would seem too early, to be able to fix things down on a computer. So yeah, I think that's how I would kind of overcome those things.

Frank: Or if you had already done six but didn't find anything, would you do another one or just go ahead?

Zak: I think it would come to how... I don't know where it's coming from. I couldn't describe where it's coming from. But I think it's the instilled confidence or the thing at that point and how it's speaking to me. It might say: "This is strong. It's not easy, now, to go into another draw". It does not seem like an easy leap. If it was easy, I think I would have to test it through a model, first. It might be, that I am doing the model and it's really not working. In which case I am just going back to the drawing, go back and do the sixth. If it got to be the case where there are six iterations, and it's... I've done six iterations and it's illogical to jump to, and it has developed slightly, but it doesn't feel quite at the point where it should be, I think, I would be resisting myself doing another one. Because if it is not working, I need to find out why. So I would probably still test it. But it might be in this situation, that I have to test it, OK it's not working, and I have done six, and I have always done six. But this time my luck has run out and I need to do a seventh drawing, or an eight, or a ninth. To get to that point where... to get that feeling that I have if it was just two drawings. There was a point of confidence, a point of, where the leap of faith is just too much. And so I'll do that. And then go and test it. And it would be the testing that kind of is that point where I go back, do I carry on work this up? If that makes sense...

Frank: So if you would switch to a different drawing, or a different scale, or a different approach, do you have a specific goal in mind for that? Something you could verify your results against?

Zak: I think the performative sort of side of it, or the technical point of it, comes to a point where… Because there… in the academic sense there is a deadline. In the real world it might be a meeting with a client. So in either way there is a deadline. And you need to allocate a certain amount of time to produce those images, in order to meet that… And so you know, that actually, in order to allow yourself that time, you have to give yourself the previous deadline. So it's about, how much iterative stuff can I get to that point before you work out those final drawings. So that deadline you set yourself, you need to resolve these schematic things. And you need to resolve those technical things. So I think it would be about what you've got to that point. So you think to yourself, whatever I've got, I need to… Speaking in terms of how it tends to happen versus what should happen. So kind of get your scheme. And you say, right. So how am I gonna plug in these performative things. So I know I've got a wall there, it's not a window, it's a wall. So what's my u-value calculation gonna be for that wall. What that starts to do, I think is it… You say, OK. Well, initially I thought that's plaster and that's a brick. And then there is a cladding, but actually, maybe it's another brick wall. And so you can conduct an u-value for that. The u-value tells you, actually that's meeting what part bababa building regulation is saying. So I need to look at other materials that are gonna make this wall conform to this requirement. You might go around in a few circles. You might actually make recordings of these previous attempts to actually meet this u-value. And you can say, look, I've tried this… And then you might get to a version actually does make the u-value. It might not be exact but it's close enough or it's better. So you say OK, so that does that. That's meeting that outcome that I'm gonna be assessed on. So you can kind of sign-post that. And say that's for that. You can repeat that element for maybe a roof structure, or a floor structure, or you got a window. And so you start to… That would obviously have a lead to the reality of things because you have to meet those certain requirements.

Frank: I meant earlier on, so before these external regulations come in. Is there something you impose yourself on the next step?

Zak: That's what I am thinking. Because that's what tends to happen. What I think should happen is that you set those requirements earlier on in your design process. So it might be at the stage where you produced… Oh no, I think if you are massing it, in the 1 to 500, it's too early. But once you get to 1 to 200, and you have roughly sketched out a plan and sections, you could already begin to think that the roof or the walls have those requirements. They are in the law. And if this was for a client or a real-life project, you'd have to instil these performance things. So actually at that stage you could begin and look at those things. And say, actually, in this early stage, I need to do this. It might mean that you are not so conscious about doing another 5 drawings as you are about to be applying these parameters to that one drawing. And it might be that through those parameters you can maybe... you either sketch or diagrammise those things around the image, but actually from that you could do another iteration. But it might be the performance things that, in this case, drive the next iteration. As so much as well, I have drawn a series of lines, let me draw another series of lines - it's performance based. If that's what you meant by that? Yeah. But also for the 1 to 500 you have to decide when to stop at some point. So is that a feeling or is that something that you define at the very early stage yourself? Generally my 1 to 500 is: each of the spaces that I know that I should or I would generally need to put in my building programme, and they are all printed as individual blocks. And they would be repositioned on a map on the same scale of 1 to 500 showing the context. And in my mind, I'd be a user and think where these blocks would go in terms of a user. And then through each sort of iteration I am trying to begin to structure those components. And trying to get to a point where, I suppose, it becomes harder to orientate those objects. And it's that feeling then, that is. It's not about being stuck... It's not a stuck thing. I don't need help. Or I need to scrap and redo. It's that thing that is saying: Well, test this now. Do it in a different way. Because it's kind of a pause thing, this stuck point. And the testing. Which is actually the same thing. It's the same feeling. It's about, you've reached the point where it's difficult to move on. So maybe you've gone to the extend of whatever it is. So actually, I am just thinking about different solutions now that we are talking about it, it could be that you have a conversation with somebody about it. They might come up with something. But in a way, you are still testing it. You are just testing it through somebody else. Yeah, I think it's a feeling. It's a feeling of pausing. It's a feeling of taking that thing in another direction. And testing it, even at that stage.

Frank: So in your testing, do you actually take the position of a persona or a stakeholder of the process?

Zak: Or are you still yourself looking at it? I think, in the 1 to 500... You are thinking about it in terms of the client. Because all your research up to that date, would be putting yourself in the shoes of that person. So you might actually go and meet. If it is something about someone who is involved in printing, perhaps. You would go and meet with the printer. You'd go to a print house. And you ask. You do this research. You interview. You walk through the spaces, you maybe photograph, you make sketches. You put yourself in that occupation. You are translating that. Because you are still trying to say, these are the spatial requirements. You are still in their shoes. I think if you get to that point where you are kind of pausing. Or you are saying, I can't go any further, you begin to test it. I think you switch roles in a sense. Because you have gone as far as you can at that point. In terms of being occupative about it. And you need to say as an Architect, I need to... I know my requirements in terms of spatial, I know what the occupational needs are. How am I going to achieve these for the client? And I think it's that pivotal thing from massing to, in a sense, testing. It's that hinge, that allows you to switch roles. And I think I see the tutors, I see the tutor as a client, essentially. They are the ones that are going to review that this thing as a client would. So even if it's just the tutor, before a big deadline, you need to be able to explain how you tested the spaces in order to meet those requirements that the client has set upon you. And it's... unless you have tested the work that you have done previously, you can't actually know if it's working or not. So I guess that's how that might work.

Frank: And you also said something interesting earlier. You said, you are going through the spaces. So what other influences do you have on your work?

Zak: I look at the site. I think looking at the site is as well...Maybe it's about producing sort of a narrative for those spaces. Generally I like to perceive spaces as processes. So if it is a printing thing, it's about what happens first. What happens next... And actually, so there is something about what feeds in to that initiation. And there is some form of outcome and what has been produced. And so you can start to think about the external things outside the space that you created have an influence, and maybe influence themselves backwards. So how your spaces become dependent on those that initiate your programme. As well as spaces that have then a dependency in terms of, they are depending upon something you are producing. So maybe it's actually reciprocal, maybe they are giving something back. I like to think about those processes and narratives that allow those sort of things. To think about how your programme, your building, might relate back to this context. But also, something I started to do recently, is just to take a sketchbook, take a pencil. And I might even be speaking out loud, because I do it, but in my head I'm stepping into the building. Where am I going next? I am going here, and then I'm going here, I'm going up there, and I'm going across here. Then I'm going to do that task, then I probably go here, and then I am going back here. I am going to go there, I am going here. The product, whatever it is, is gonna go maybe that way, but I don't go where the product goes. I go back to that space because that is how I exit the building. And actually, the pencil hasn't left the paper. And I have this kind of journey, that I've drawn out. And actually, from that, you can take that image, print it out, and you start position spatial settings on this journey. Because you've allowed your mind to guide you through. I think that's another way of me trying to transcribe how I might begin to look at that sort of setup.

Frank: And are you talking to other people as well, maybe not Architects even?

Zak: Yeah. And actually, in a similar way… I think it's good to have the conversations. I think things that I don't know if I should be conscious of them, but I am conscious of them… One is the idea that if you talk to someone, it might be that they try to come up with suggestive ideas for it, but it might be, and this is the thing I am conscious about, they are suppressive about your design to better their own. Or whether those designs are actually constructive in a sense that they help you to do better work.

Frank: But that's mostly for other Architects, isn't it? Do you also talk to other people about your designs?

Zak: I think when I talk to... I get the general consensus, that when I talk to other people, for example if I talk to my partner, I might talk to her, I get the feeling that she is not interested in the subject. It might be that she is not interested, it might be that she doesn't understand it. She might not have enough background knowledge, or terminology, or processes that happen. And so that field of Architecture isn't interesting for her. So that becomes hard. I think some people are interested or are stimulated, such as my parents, because they want to know how well I am doing at the University. They become intellectual engaged with what it is I am doing. Although the technicalities of it, in any given sense, become more of a blur again. Because they don't have that background of understanding. But I think by having these conversations, what actually I do I free up those ideas that I am holding on to in my own head. And allow me to give myself clarity. Allow me to actually think about what else it could be. How I, you know, can actually go back to my design and actually come up with some other concepts. But I think if I do that, I need to be conscious of what it is that I am coming up with, what it is that I previously got. And is it an evolution or is it a discarding of something? And how do I go about to maybe saying to the tutor, you know, this is what I have done. Have I discarded something? Or have I simply just adjusted it, you know, have I evolved it? Or do I have work that documents or lead on from that. Understandably, if it's discarded, how do I represent that as being discarded. How do I represent what I have now got to? And what is the thing in between, which is why have I done what I have done? And that's generally what has come out when I had that conversation with someone that freed up my mind. Yeah, I think I know where I want to go in my future. I know within that constraints, that I have to finish my first part of my degree, I have to get some experience. I need to do a masters programme. I need to get more experience and do a part three. And then at that point, I've only a number of years of experience. Is it beneficial to maybe go and work for somebody then? How long? I don't know. There seems to be a stigma about things being five years. Five years seem to be a suitable amount of time. Do I then spend my time contesting that? Try to understand why that might be? Or do I just fit in with it? You know, do that for five years. But I know, at the end point, I want to be working for myself. It's just that bit of vagueness in between. But I think, previously... Because I've got this ability to assess something to an extend, maybe that comes back to that I say I do six iterations of something and I know that's a pausing point, I think what it does it entrusts me with a certain level of confidence. So if it was about working for it for five years, I might actually before the five years say to myself, actually no! I'm confident now. I can jump that and go and do the thing, which I know in my head is what I want to achieve. Or it might be that I do five years, and I am getting that feeling of confidence. So I work longer. But I still know that the end point is working for myself. So I do have those conversations with myself. And actually I think even before I get to that part about finishing University, I think within myself, I can look at a piece of work and I can critique it against something other. I know I got within myself the ability to know what I like. I know something that I have seen which actually I know what the task is the output in order to meet the assessment. And I can contextualise that piece of work that I like with what the output is. So then I know why I like it. I know why it is doing what it is doing. And then I can use that to reflect my own work and say this is why I am not doing what is as strong as it could be. Because this other piece of work has given me a gauge in which to set. So I have those conversations with myself.

Frank: So is this years work influenced by last years work, for example?

Zak: I think what its about from last year is understanding basic principles. This year it seems that they are related in a sense that they apply to the field of Architecture. The school decides that the elements that we have done are going to be assess again this year. But actually there is some kind of level, there is adding a level of, level of... I don't wanna say hardness, it's not. It's an increase in the academic level. There is some parameters that might apply to that. So it might be that we are doing a technical report. And actually the technical has to with thermal efficiency. It might be to do with structure. And it's the same things that we have learned about in the previous year, we can still apply to this year, but actually, you are going deeper. Which adds that level or professionalism. This academic level to it. I feel that those things become transferable. And as long as you have basic understanding of things, it's easy to apply them. But then you kind of begin to go into another field of learning, which is about those elements that apply to depth what you currently know. So that always building upon that, if that makes sense.

Frank: The group you are working in, is that helping you?

Zak: At the moment it's a little bit of a hindrance, in terms of, I suppose the body of work that needs to be produced within the time constraints. Because obviously, the number of people versus level of work can actually reduce the amount of work any one person within the time frame. Depending people's individual personalities and ways of assessing things we are doing and individual time tables, that can have an impact on how that work gets produced. I think the idea of being a member within a group actually helps overall. Because it allows you to consistently being stimulated. It allows you to test your proposition amongst all of those different members. And actually, you might be testing it with each one. There might be overlaps if you rigorously test it with two members at the same time, or maybe it's all five members. There are overlaps, there are crossovers and the project becomes very very strong. And I think as those things come out, you don't necessarily achieved that by yourself. And that can instil confidence in yourself. So the group aspect does help.

Frank: Thank you, that was a very interesting conversation.

1.9 Interview with Peter Kemp

Peter Kemp: So what do you want to know?

Frank Loesche: I want to know how you create. So maybe you can tell me how you do it in the course? Do you start with the brief? Or maybe even before that?

Peter: I think it depends entirely on what sort of brief or project it is. Depending on if we know who the client is exactly, or if we are making the client up.

Frank: So what's the case for the Derry's cross project?

Peter: For this project we are looking at how the Plymouth City plan and the Plymouth city council are looking for new ideas for the city. In a way the client is the council. And in a wider sense the city of Plymouth. It's sort of trying to create more civic space. I think that's the sort of first thing we started to look at. It was about what we felt civic space would be. What would be helpful in a city. And then, first of all, we looked at the Abercombie.

Frank: What's that?

Peter: That was the plan that was made initially like post-war to redesign the city. So how about this kind of came into being. How about was it then implemented. And the successes and failures of it.

Frank: So it is considered to be a modern city, Architecture wise, after the war?

Peter: Yeah, yeah. Because a lot of Plymouth in general was bombed. It had to be... Because the plan... It had allowed to be taken down. And then, sort of, Armada way, Royal Parade, and the Western Approach was then coated around the city. The Marked changed position. But we found that by looking into maps from 1890. And then comparing to maps from, maybe, 1960s.

Frank: So where did the market used to be?

Peter: It used to be more in line with sort of bottom of Drake Circus. So it had a much more celebrated position within the city. Now it's totally put into the back. Which... with anything that's built up around it. So it kind of gets a little bit lost within everything else around the market, which is a shame. Because the market, it's like an everyday event... You can go, you can pick up bits and bobs, gather the food for the day or the week, however you want to use it. I think it's a shame that it lost that kind of focus with it. Yeah, so I think, we initially looked at how the shift changed from pre-war to post-war. And how the city is very dense. And it was very mixed use. So, how before it was all of the ground floors were shops and the commercial side of things. And as you went up, it got more and more residential.

Frank: Are there still residential areas down there?

Peter: There are, but largely it's storage for shops that don't need the storage. So they rent the land, so that's three to four stories. And they use the bottom and the other stories are used extremely poorly. So it's just an inefficient use of space. We found out, that shift obviously pushed a lot of people out of the city and then made the east and the west of the city more exposed to the connection to the town centre. And how the Western Approach kind of acts like a barrier between the residential area above Union Street and then into the city, into the market.

Frank: Is that your own observation, or did you also talk to people in the area?

Peter: Yeah, I think we looked at plans and maps like from a hundred years ago and more recent. We then looked at… We then did figure-ground studies of where residential units were and where they are now. There is a lot of smaller units back until 1890s, and they were more people focused. They were a lot narrower. You were made to engage with your neighbours, the terrain, everything around you. And I think, making these sweeping gestures, like the Armada Way, it becomes very kind a sole if you are walking around that area. Because, again, I supposed, what we were doing is seeing the failures of it. Because if we understand what doesn't work about it, we can then attempt to not make these mistakes again. And I guess that's how we start the process. It's addressing exactly what the issue is, and what the plan wants.

Frank: Did each of you do that individually, or did you do it as a group, or was it a mix?

Peter: Very mixed. Sometimes you went to the site all together, and sometimes you went to site as one or two. I, for example, went down and took pictures of all New George Street, and of Cornwall Street. The shop faces. And then piece them together to a very long texture. And then from that we looked up what exact shows were occupying the space. So there was a lot of… If you move down the street, as you walk further towards the market, it became less of the shops, and smaller ground, and went from being three stories to being two stories. And there was a definite shift in focus between shops that were nearer Armada Way and shops that were nearer the market. And they were allowed to be more run down the further you get down that way. And there were fewer independent and Plymouth oriented shops and selling things that you wouldn't get anywhere else. So I think the point of... We have picked up on how the shift changes. And then we kind of thought, we want to change that. We want to add in more local produce which celebrates the locality of Plymouth. So we then kind of talked about how we could do that. Maybe farming. Implementing like an urban farm. So, around that, we've got... We have one person who is implementing a local farm for growth and maybe teaching.

Frank: So you basically went down to the site, identified a need for local produces. So you came together and made the decision to have a farm and then went off? Did each of you decide individually what you wanted to do then?

Peter: Yeah, we all decided. We had the main focus on the market. And initially we were trying to commit the market to Derry's Cross and make it more about the theatre. So making Derry's Cross more of a cultural hub. But we then found that distance is quite far to bridge that gap with all of our projects. I think, if there was maybe more intervention allowed, more projects available, then we could have made that distance work for us. But we shifted our locations around, maybe 15 times. And eventually we found that we need a market square just like the one next to the market that is currently used as a car park. So we had to iterate, and iterate, and iterate, before we got to our locations.

Frank: So how did you decide that this was the right location to work on at the end?

Peter: I think we looked at what we were trying to do with our propositions. For instance, I was going to act almost like a gateway into the rest of the project. That directly let me to decide on the location. Aisha as well. She was also doing like gateway, but from a different side. So we were both gateways to start and finish off the process. And then Bobby's was a tannery and a butcher. So they are connected quite heavily, because the butcher would use maybe five cows a week. They would be located on the site as well, for grassing. So they would be breed elsewhere, and then brought in for the last few days of grassing. And then using the skins from the animals, they would go to the tannery. And from there they would go on to become some produce. I think for us it was about utilising every part of the process, no matter what process it was. So each of our waste products could go into the next programme.

Frank: Is that something that applies to your creative process as well?

Peter: Yeah. I think you think through things so many times in your head when you walk from the studio, when you walk from home, when you are walking around. I think getting out of the studio is very important, because that is when you have your best ideas.

Frank: Why do you ever come to the studio then?

Peter: To put them on paper.

Frank: You could take paper with you...

Peter: I always do. I think it is obviously important to work through things on paper as much as it is to have those ideas and think about them. And I think actually drawing it, then you actually put it from your brain down on the page and then you can come back to it later and pick out elements that work very well, and leave out others that don't work so much.

Frank: How do you decide which ones are the good ones?

Peter: Partly just testing. Testing, modelling, imagining you being in the building, in the space.

Frank: How do you test?

Peter: I supposed, at the beginning through diagramming how you want the space to work.

Frank: Mostly in a sense of spatiality?

Peter: Yeah, spatially. Or say, if you want a space to feel very open or very tightened or constricted, how others are feeling and how do you want it to come across? And then within that you think about how you would interact with the space. And maybe you would sketch out the use of that. And take that one step further, maybe you make some models. And from that you can see how the light interacts with the space. And when you sort of created a physical kind of form to it, the more models, the more details you can bring on to it, it helps you to move along.

Frank: How do you model? Do you do it digitally?

Peter: Sometimes by hand, sometimes on SketchUp, or 3Ds Max

Frank: Why do you sometimes do it by hand and sometimes on SketchUp?

Peter: I think it's very easy and quick to create to smaller CAD model of what you want it to feel like. But that has a very different feel to when you look at an actual 3D model. Because it's a difference if you can only look at it on screen or if you can actually pick it up and just manipulate it through the movement in spaces. In past projects I have maybe made like 5 or 6 different models for each space. And then moved them all around. And changed the orientation of certain elements of them, and photographed them to document the entire process. But that was just from one quick model. And from one model I made maybe 30 different interpretations and combinations of spaces. And from that I can see things that work, things that don't work. And then push that along further. It kind of goes back to the iterations, seeing what works and what doesn't.

Frank: So you basically sketch ideas first, then put them into a model and test if it works. You then identify the elements that work and don't work and then go back?

Peter: I think, at least for me anyway, it's less about what doesn't work, more about what does. Because sometimes what doesn't work for one thing, could work for another part of the design. So even if... Like last night I came in and made maybe five models. Not because I thought they would be right for what I was doing. I just though if I would install them, maybe I see something completely different. Because how you imagine things, that's not always how it comes out.

Frank: Why is that?

Peter: I think people have different emotions about what things can be or what things should be. And I think it's difficult to really imagine a space that isn't real.

Frank: Are you showing these models to other people as well or is it mainly for yourself?

Peter: I think it's primarily for myself to rush through that process. I think, part of it... I think if a model becomes successful and it leads me somewhere, then I use this or the documentation of that process. Because it might not be the model itself, but it might be a photo taken from a model that sparks and idea. And that can take you on a completely different route.

Frank: If you take pictures of a model, do you keep all of them, or do you immediately delete some of them?

Peter: I am usually quite bothered by deleting pictures, so I usually just keep them all.

Frank: Was that ever useful, or is it just a habit?

Peter: Sometimes it's useful. It's always good to keep past things. Because then you can flick through old sketch books and see what you saw years ago and it kind of awakens an idea. And that's the same with models, and sketches, and pictures.

Frank: So if you think about your past, do you also think about your future? For example where you might be in five years from now.

Peter: I could probably have a guess where I think I'd be. I would like to... I think I'd be finished with this course, be graduated, and work as an Architect. However, I might be doing a Masters or something. It could be completely different.

Frank: I mean in regards to the type of designs you are doing at the moment — does your projected future play a role there?

Peter: I think for some people, yeah. For me, I always find new things that interest me, which is probably quite bad. In a way it's good, in a way it's bad. Because I think I get quite distracted. And I think I really pick up quite some odd skills and things I don't need to be learning. But then I do. I did like a lot of kayaking, climbing, hiking. Do some outdoor stuff. Travel a lot. I love to get lost and find a way back.

Frank: Does that somehow resonate in the project you are doing right now?

Peter: Maybe. Maybe that's how I view lots of things I don't want right now. For instance, that we as a society, as a species, eat too much meat. It's unsustainable for the amount of people on the planet. You can't advocate that there being less people without quite some big confrontations. So we have to look ahead on how to solve this problem. And I think it's not outside the responsibility of Architects to look at these issues. Because it affects everyone and if the Architecture of a city can bring the people more together, more sensible about food and local produce, then that would be a great step forward. I think it's long term. And I think my research hasn't really gone to many places, yet. I'd love to look into more. Maybe that's kind of my next stage. I'm always wanting to do something that pushes me. And I think the studio that I am in at the moment is the one that made me most uncomfortable. So that's why I went down that route. Because I don't think you'll learn anything if you do the same things over and over again. If you are getting a pad on the back for the things that you can do, there is not a lot of point to do that. But if you try, fail, shuffle, fail, try, that always gets you in a forward kind of momentum. I always wish to learn something from the process. So I think that's kind of the main thing.

Frank: So you are reflecting on the process itself as well?

Peter: I think I do it a lot of times by not really thinking about it. So if something doesn't work, I just move on and try something different. I should be documenting that, so that later I can look back what did or didn't work. For me it's very much the process how you get from A to B. Because it's not just one way of doing things. For example here in the current studio, if you are working on the same project and you all have the same starting point, no two projects will be the same. Because everyone is bringing in their past experiences, their past failures, successes, everything. They put themselves into the project.

Frank: But if you put the same people in the same space again, why would it be different?

Peter: Because we are all human beings. People are different. I think people are so varied, and that's a great thing. That's probably a reason why social housing doesn't necessarily always work. Because if you are designing for a group of people which... You are designing for the average, and the average doesn't necessarily exist. It could be working with everyone and it would be lovely if it was as easy as that. And people are unpredictable, changeable, adaptable...

Frank: So do you work with persona to put them in the position of stakeholders in the project?

Peter: Sometimes its subconscious, other times its very conscious. Because it would be kind of silly, to just at your wants and needs for a product because you are probably not the person using it. You can do your best to maybe look at a group of people and how they would use the space. That would be defining the user. That would be an initial step.

Frank: Do you also talk with non-Architects about your work?

Peter: Yeah, when I get home. Yeah, I think it's good getting different opinions on things. We all create some kind of microcosm of thought in the studio. As much as it is good to talk with other people in the studio, I think it's better to talk to people out of the studio because then you don't get the same kind of ideas going round and round and round. So fresh eyes are very positive, because then you get a fresh take on to things. They might not be as educated within the profession of design, but they might see something that you completely overlooked, which could be a key feature to a design. And maybe that's what takes it from just a stack of building materials to something meaningful to a community, to a place.

Frank: So talking about materials. Does that play a role in your design? Is that something you consider in your design process, or does it come in very late?

Peter: I think as I go on and design more and do more projects, and get a greater understanding on what could be done, that will change. Just as the technology that you understand limits what you can produce to some extend...You can have all these wonderful ideas in your head. If you can't put that onto paper, if you can't put all these structured on a paper on an actual design, on an actual working structure, then it's not gonna mean anything. Your knowledge is a limiting factor to what you can and can't do. You know, the tools available to you, are a limiting factor. I think the library is a great resource to go to. I think people tend to overlook the wealth of knowledge that is in text and rely way to heavily on online journals, online resources. They tend to look at flashy, very well illustrated things, like Dezeen or Artdaily or those design websites. They are nice to watch or to view. But sometimes they are very far removed from actually gaining knowledge. They are pretty pictures. And they are letting you gaze on them, but you are not getting much from them.

Frank: How does knowledge relate to your project. Do you think you understand the problem from the beginning?

Peter: No, I would never say that I understand the problem. Yeah, I think you have to learn about the problem as you go along. I think to assume that you know anything, is a limiting factor again. It always holds you back. I think being open to new ideas, to not knowing... accepting that is...

Frank: But you need to know at some point, right?

Peter: No. I think you work towards a point. At the beginning, I think, you are very open. Because otherwise you are just gonna be making the same building.And it's not gonna be... It could be spot on. It could be absolutely great what's in your head, but then, if you draw it out four or five times, you might be seeing something that you didn't see prior to that. And then you keep drawing, keep iterating, keep changing the process. And you keep creating those different output. And you might work your way back to the start, but if you work your way back to the start, then you know that that's. That your first instincts were right in some way.

Frank: So if you had unlimited time for this project, would that be a good thing or a bad thing?

Peter: No, I think that would be a bad thing. I just spent weeks or months doing a painting when I could have probably stopped after five days.

Frank: Is it just not progressing after some time or is it getting worse?

Peter: I think it's just done when it's done. But when it's done it's hard to sustain. It's hard to know when it's completed. I think sometimes you just have to stop, take a step back, and get yourself out. Try to see it from a lot further away. And that might tell you when it's completed. Because for example with the painting or drawing, it's hard to know when you finished something. Because sometimes it's five or ten steps before you think it's done.

Frank: So does your tutor come and tell you to work something else? Is that something that might help, something that you learn during your education here?

Peter: Yeah, I think you get better of finding when, or how much more effort, how much more time, whatever you put into it, is not related to, it's not gonna be any additions to the meaning and to the output. It's finding that point. You get slowly better at it, I would say. The tutors can help with that. Nudge you into not spending hours and hours and hours on a tiny detail. As well as... Especially in our studio, they are getting you to look at 1 to 5, and one to 200 and going back further. So you are looking at it in various scales all the time switching from scale to scale.

Frank: So when is the time to switch between those scales?

Peter: Any time.

Frank: But when is the time you decide to change?

Peter: I think, first I look at the massing. Then I look at much more minor scale. Then I look how light enters a room. Then that would be a much smaller scale. But sometimes you need kind of a midpoint to see these things are not getting lost with each other. So it's constantly shifting back and forth to see what you are doing... one is complementing the other.

Frank: So you switch whenever you think one of them is achieving what you wanted it to address?

Peter: Yeah. I think it's really handy to pause time sometimes. Then build kind of a huge set from the models, and really really plan on the space. But obviously, the more experience you have, the quicker you get there with your modelling and showing it at some point. Because there was a lot of time wasted in the making, in going over the same thing because you feel save in that area. Which I do from time to time. Drawing the same thing again, not because I think I will gain anything from it, or because it's gonna add to the project. Just because I felt like I know that part a bit and that will produce another drawing that will look very nice, but it's not gonna do it.

Frank: You might use that as an anchor or a starting point then?

Peter: Yeah, a little bit. I think it's being honest to yourself. It's telling yourself you want to move on from one part of it. Of course that comes back to knowing when something is completed. Because you can work too much on one thing and then it becomes overworked. There is a beauty in things being just right. It's not too worked. It's more kind of, it is what it is. It's not too much. Sometimes I think I manage it, but then...

Frank: Thank you very much.

1.10 Interview with Amelia Gardiner

Frank Loesche: Basically, the only question that I have is: How do you create?

Amelia Gardiner: At the moment I have been working... So far I worked in plan and section, when I first started designing. I had my programme and from that I sort of did bubble diagrams. So different bubbles to show where different things would go. And then I tried to work in plan and section But in my last tutorial I found that like the way that I created in my plan wasn't really good enough.

Frank: How do you know it is not good enough?

Amelia: I was talking to one of the tutors and he said like, it makes sense, but it's not... it hasn't got enough creativity about the design itself. So it's too formal.

Frank: Did you see that yourself as well afterwards?

Amelia: Yeah, after he said it, it became really obvious. So today I have been starting to work in perspective. So I am redoing my whole design, but from an experiential point of view as opposed to just plans and sections. Which is almost as if I restarted the process.

Frank: So you are working somewhere around Derry's cross? So what exactly are you designing?

Amelia: Do you know the bank building? It's like a really old-fashioned building that's been turned into a pub, but it's a really detailed kind of facade.

Frank: Sorry, where is it?

Amelia: It's got so... The car park is there, the big car park. And then there is the Theatre Royal. And it's like the building in the middle. Yeah, so there is this big car park behind it. And I am taking out the car park and repurposing the bank building. So it's becoming an allotment / kitchen / garden / seed bank type thing.

Frank: How did you come up with that idea in the beginning? Did you walk down there?

Amelia: Yeah, we went to site and we were walking around and then we were looking at the age groups that were there. So we went into the Athenaeum and talked to some of the people there. They are mainly sort of like third age, old people around that area. And then we looked more into regeneration in general. Because it's sort of lacking in character around that area. It used to be the centre of Plymouth, almost. And now it's just sort of dead. So we wanted a regeneration sort of theme. And then it sort of became obvious that the allotments were quite important for that.

Frank: How did you decide for the regeneration theme? Based on your research you could have built more retirement homes as well. So how did you decide on regeneration?

Amelia: We didn't want to just isolate the third age. So we wanted to reintroduce the younger people. And also the student accommodation being built just right behind Reel cinema. So we didn't want to sort of ignore that demographic completely. It was the regeneration to bring those two generations together, almost. And to create a space that made sense for both of those ages at once.

Frank: So the idea started from an almost social point of view?

Amelia: Yeah, I think so. I think because we went to the site and actually spoke to people, that really influenced our decision as a whole. We liked to tour around Athenaeum and also around the civic centre, that really made the difference.

Frank: How do you translate those conversation that you had into Architecture? Do you immediately sit down and start sketching?

Amelia: I think it was a case of problem solving. So we did a lot of group discussions right at the start to sort of come to a conclusion about what would be... what would make the most sense. As well as a lot of background research. We looked a lot into the history of Plymouth. And sort of redeveloping that aspect. It was really just a case of talking until we all agreed on an idea. And then we went on from there.

Frank: Was it necessary that everyone agrees? Or would you have been fine if the others had implemented other ideas?

Amelia: I think for a coherent master plan, it doesn't make sense for one person to be on the edge, because otherwise it won't work as a whole. The one person who disagrees will always do less well than everyone else in the group.

Frank: Do you have the feeling that people had different weight during those discussions?

Amelia: I feel like the third years, and I am a second year, the third years had a lot more influence to start with. And then the second years came into sort of our own afterwards because obviously we don't have as much experience as they do. And they have done a similar project to this last year. So it's good to hear their opinions first and from that we can figure out our own mind.

Frank: So did you use their experience as input to your own process?

Amelia: Yeah, definitely. I feel like we are definitely learning from them the whole time. Because it's getting a fresh perspective on a new topic. So interesting to listen to sort of get your bearings before you sort of dive in.

Frank: Talking about fresh: I've heard before that your role as a second year might also be to bring in a fresh view? Does that reflect your experience?

Amelia: Yeah, I feel like we are helping them as well. Because we have our own things that we sort of developed at the start of second year. Because it's run differently this year. Because we are doing more CAD based and things like that. And they are more focused on hand drawing. And I feel like we are bringing in some computer knowledge, almost. And ways of working that way. And they are teaching us a lot about hand drawing. Which I hadn't really done since first year.

Frank: So how does that work: Does someone else do hand drawing, then you put it in a computer model, and then you redraw that?

Amelia: I feel like we have all done pretty similar amounts of everything. Because it's all our individual designs that we are doing. But then there are some things that we are better at than others. I found that I am strongest at tracing and creating details for bigger drawings. So I have been doing a lot of drawing of historical Plymouth. Which then go into bigger schemes. That's sort of been my job through this part so far.

Frank: Do you always keep in mind, for example if you are drawing those details, what the big overview, the whole project looks like?

Amelia: Yeah, definitely. We had like a layout of what it will actually look like and I was given the section to then work on. And then I reintroduced that back into the drawing.

Frank: Did that also change the big drawing whenever you did something or were you mostly filling in gaps?

Amelia: Yeah, a little bit. The way a drawing is done really influences the rest of what's surrounding it. Because it's that style. It didn't make sense for anyone else to continue drawing. Because that would then clash with that style of the drawing. Did you then translate that into CAD as well? Not necessarily that one, because that was historical Plymouth. So it wasn't that relevant to create CAD drawings of it. But for my own project... I haven't started CAD yet, because I often rework that design a lot of times. I really haven't gotten to the idea, yet.

Frank: You are doing mostly hand drawings then?

Amelia: Yeah, so far. I have done a lot of iterations on tracing paper. Just like hundreds of sheets of tracing paper so far. But the last project I did a lot more CAD drawings because I was more certain about my idea earlier on.

Frank: Do you currently use the same scale all the time then?

Amelia: I have done a lot of 500 and 1125 working in plan, because you want to see the wider context. But I feel like you have to work in a variety of scales. So like understanding your building as a whole. So if you don't work on a smaller scale, you will never know the technology and certain elements of it. And then if you don't work with the wider context, it won't make sense with the rest of the site.

Frank: What do you base your decision which scale to use on?

Amelia: I think, if I want to focus on context, it would be more something like 1 to 1000. But if I want to focus on technology... I feel like I zoom in as I go through. So I will start off with a really wide scale and as I develop I zoom in. I know that you are supposed to work on small and large scale at the same time, but I find that quite difficult, so I always go from larger to smaller.

Frank: OK, so you zoom in, and then, do you zoom out again, or do you just stay there?

Amelia: Maybe zoom out at the end, to see if the final... So when I got the facade and things like that, like, decided, then I zoom back out and put that in a context. But I mainly zoom in to start with.

Frank: You mentioned earlier that you now changed to perspective. So what changes for you if you do that?

Amelia: I think it's more about the experience. Seeing how people interact with that space, so even if you don't really know what it's about. So you start deciding like key circulations, and probably aesthetics when you are doing a perspective, rather than the layout. And then from those things you can decide on the layout rather than the other way around, which I am finding quite helpful.

Frank: So is the aesthetics mostly based on forms? Or what else do you consider?

Amelia: I think I often base it on a wider context. So I look around at the site. So that's really key at the moment because I am working with the bank facade, which is like a really complex sand stone design. And so going with anything too complex, or too similar, isn't going to work out. So you can't really replicate that style.

Frank: Are you looking into the type of stone and other materials as well?

Amelia: I think the surroundings are the main thing I focus on.

Frank: And light, I guess? Or is that something that comes in later?

Amelia: I think that's more interior details later, and how different things are highlighted as well.

Frank: So after the perspective drawings, what will be the next step?

Amelia: I think from that I'll go on to plans and sections. Because I think I will be in a better position to do it then. Rather than just diving straight into that like I did at the beginning, which didn't work out.

Frank: Do you also build real models in addition to CAD?

Amelia: Yeah, I made one so far. I probably should have made more. But I think that will go again with the next steps of plans and sections. When I have an idea in plans and sections, I can make them more 3D and work out from there.

Frank: What do you use the models for? What do you want to learn from them?

Amelia: I think it's more like a realisation if an idea that looks good in plan and section, could actually work in real life, because you are putting those things together and you see how these things interact.

Frank: So how do you decide if it works?

Amelia: I think it's just a case of looking at sort of scales. So thinking about it from a human perspective. If something looks ridiculously small, it's a sort of sense that you've gone wrong somewhere.

Frank: So it's basically experience that you already have with existing models?

Amelia: Yeah, yeah.

Frank: Do you move the models around as well, or do you just put it on the table and walk around...

Amelia: It's always helpful if there are models of other people in the master plan as well. That is something that really made a difference with the last model that I made. Because my building connects to someone else. Seeing that connection in model form is really useful, to see if that works together.

Frank: If you look at those models — by the way, are they made from the same material?

Amelia: Similar, not quite the same.

Frank: So they have a different texture, maybe a different colour?

Amelia: Yeah, we are working both in cardboard, I have just been using a different card board to the other person. Out of accidental almost, no intention.

Frank: Did that have an influence, would something have changed if both of you had used the same cardboard?

Amelia: I think as of now, it's alright, since we are mostly looking at form. But I think when it gets more to a final model, it will make more of a difference. Because you will be able to see it more of the way of the intended materials and their representation and how they work together.

So if my building is a completely different material and design form the person next to me, it's gonna really influence the site.

Frank: So if you are looking ahead, do you already plan for what to do next year?

Amelia: I think I want to learn how to use ArchiCAD. Which is something I am really struggling with at the moment. But I know it's important in most practices. So it's something I definitely wanna do before it gets to the point where I am applying for part two. Because I know it will help me to go further. I can get into better Universities for masters. That's definitely something I wanna look up next.

Frank: Do you also have a vision of yourself in 10 years from now or does that not really play a role right now?

Amelia: Yeah, I think so. Before I came to Uni I did a work experience that I got out of complete accident in a place in Shoreditch in London. And that really inspired me and I wanna do something fast paced like that again. It was not a huge firm, but it was right at the centre of London and they do a lot of variety of things. And I really enjoyed being in that sort of fast paced atmosphere. Even if it was just for a while, but it was nice to experience it.

Frank: So how did you become an Architect then?

Amelia: I think it was, I was really into Arts, and I was really into Maths and Physics type of things when I was younger. I was less into Maths and Physics when I got older. But Art was really key for me and it was putting Art into a real world situation. That was sort of the main thing that threw me to it. But then I also decided when I was like seven, that I wanted to be an Architect out of nowhere. So it's those two things coming together.

Frank: Is it still the thing that you wanted it to be when you were seven?

Amelia: Yeah, I can't imagine doing any other job at this point of time. A lot of other people degrees that go in a lot of different ways, but I think with Architecture I am just like sure that I wanna carry on with Architecture..

Frank: Thank you.

1.11 Interview with Spencer Barnett

Frank: All I want to know is: How do you create? That's an easy question, but maybe not an easy answer?

Spencer: I don't know where to start.

Frank: OK, so how do you start a project. For example for the Derry's cross project, how did that begin?

Spencer: To begin with, what we kind of looked like for us, was... I was kind of looking for an aerial view, a plan, and taking in everything that is around us. Like a macro, a micro view. So maybe on 1250 scale.

Frank: So even before you went down there? Or do you already know the place?

Spencer: I kind of knew the place already. I went to the gym last year quite a bit, it's right in the centre there. But I looked at it where it was on the site. And sort of deciding what was around there. And then we went down there and took quite a few photos, which is quite enjoyable. The first time we went it was quite rainy, so quite miserable. But after a few I went down there and the weather has been a lot more better. Started looking at all the way the people were interacting with all the buildings. Like, we asked questionnaires as well. We printed off quite a few. So like asking locals. How old they were, what their purpose was that day, how long they spent in that area, if they are from Plymouth, and their transport, and everything. Purely for us and the building style that we wanted to create. We found out some quite interesting stuff. Like a lot of the elderly people would always come throughout the day to play Bingo at the Bingo hall. And they would always get the bus. So they were always quite short for time because they got off the bus, go get for the Bingo and then go off from Bingo straight to the bus. And there was always like no time in between. So they were always rushing. They were not able to stop, unfortunately. We were kind of able to guess their ages. And then from there we went on back to the plans, back to the drawing boards and how the surrounding areas of Plymouth and what we want to create with our sites, like our programmes. And we are doing vernacular, like redefine vernacular. So we are looking for like originality. Like creating spaces that suite or that used to be in that area anyway. So we found out that the bank, my site, which is near the civic centre, it's like the Weatherspoons, that used to be like a central area to Plymouth. Quite a long time ago. That was quite interesting. Near there, there is the Athenaeum which used to be, well it's a place of knowledge. So it got like an archive in it. So we looked at like archives coming on from there. So out of our four, we got a group of four, we are doing — it's all kind of archive based. So we got like a memory bank. Photography, which sort of involves...

Frank: What's a memory bank?

Spencer: That's his sort of programme style. So he is looking at how to create memories and how to record memories. So you got photos, voice recordings... We got Hannah's, which is more like greenery, environmental. So she is looking at creating a seed bank. There is one in the Arctic, I think, which collects one seed of every fruit seed of every single plant. So just if there ever was a, I don't know, an extinction of a certain species of a certain plant, they could bring that back. Which is quite cool. And then you've got other things such as... I am going into, I am doing a knowledge bank, so a library. So I designed something that incorporates everything I know about libraries. So people... A place to sit, a place to enjoy and read, or maybe you've got a coffee, for example. If you are enjoying a good book and need a drink. Hot or cold beverage. A place for, I don't know.... Either for comfort, or maybe just for.... So if you are reading a novel or something, you can have a nice leather sofa and it's quite relaxing. You can imagine, you can immerse yourself in that space. Or you've got a, I don't know, a scientific book that you are reading and you are trying to do essay notes or something. So you want a nice wooden table that's quite solid. You feel like you are prepared writing these things down. So these are two contrasting... You wouldn't wanna be in a leather sofa on a wooden desk to write, that would be difficult. So you create different rooms for those different spaces.

Frank: So why did you chose the library. Are you going to the library often yourself?

Spencer: Yeah, that's the thing. I enjoy libraries, it just never has that feel. For me the university library is great for doing work at night, because it's open 24 hours, but the books I usually get on Amazon or I borrow them off someone else. I don't know. Or I find them online. There is a lot of paper online, there is a lot... because I'm quite lazy. Anyway, so it's difficult. It's more of a, trying to bring the community back in. And make that feel that the library is open to everyone. It's reinvented. It's not just for knowledge. It's for people to come together as like a social, the more of the humble academic idea. Groups of people coming together. Like a guild almost. Come together, share knowledge, and then talk about it. Which is interesting, because that's what the Athenaeum does as well. They have classes of people come along and they do like painting, drawing sketches, and they set up in one of the rooms that looks over the rest of the site along the roads.. So seats like that overlooking the street, almost like a lounge, is one of my ideas. That was kind of bringing ideas from different aspects that I could think of as well. And then look on present ones online. Like different libraries around the world. The Western and all sorts... Then you've got...

Frank: So you essentially take those elements and put them together? Or how does you process of creating new things work?

Spencer: I look at different ideas, and then I take chunks and bits that I enjoy. That was quite an interesting process. I've always quite like being... having a room, specific room for specific purposes and whether or not it's one large room that has multi purposes, or individual room set up for specific ideas. But, as a child, having hidey holes or little place only you get to or only you knew about it in the attic or in the roof and where your parents wouldn't really know about it. Having a bookshelf like a secret like a back that opens up and you go in there to a room that is your own. And there you are not gonna hear anyone else. The ideas of having books covering the entire bookshelf. But then, if you find a certain area, you could pull open a door. And it would always look like a bookshelf. But you could actually go into a room that then had accesses for your technology, like a computer, a desk, a chair. That could be quite nice. Kind of integrating that kind of stuff in. Whether or not I would want to have a certain kind of light in that area, or have light into that area.

Frank: How do you design for that? Or more general, how do you get it out of your head into the real world?

Spencer: For me... That's the trouble. That is a lot of different ideas and trying to bring them out on to the paper. So I started off. For me I started out and draw in sections, where the public spaces and where the private spaces were gonna be. And then decided, that each room, where about it's gonna sit in relation in the building. And then looked at plan, looked at how the public spaces outside and how the building was gonna start to shape as well. And where the light was coming in. And how people would move through the building.

Frank: Do you just imagine that from the section?

Spencer: Section, elevation... I have created 3D models on my computer.

Frank: So how do you go about that? Do you start with a section and then do the computer model or both in parallel?

Spencer: I do both. I try to do both in parallel. If I get stuck, I find if I go to 3D it's a lot easier for me to develop my ideas. If I do the sections on the computer, then I can create a 3D model quite quickly. I can look at it and show people. I am not great at articulating and trying to explain. So for them to then understand or for me to bounce off ideas this is quite good. Yeah, sometimes I do sections and then look at how the building is oriented in comparison of light. So if I wanted a room with a lot of light, I would put it on the south side. And then elevation kind of helps. Because you can do that in exactly the same, and look at the plans of the entire site with the buildings as well. So it's not like jagged. And that helps with topography, with elevation and section as well. Because you have underground, have above ground. And then doing it again on the computer with 3D models, that also helps me to orient everything again. And then work out scale.

Frank: So what do you see in the 3D model that you don't see in the section?

Spencer: It's the scale, possibly. It's more like I can see, I see how everything fits together. So you've got. It's quite easy to draw a set if steps, and then draw a person that's like out of scale. It looks great in section, but then if you put in in the plan, it looks kind of out of place, because it's taking up a large amount of your area, just for some of the steps. So if I put in in 3D, I can see both at the same time. I can see where it is oriented in one plane and move it about and see if it fit a bit better. And then I can go back to section or elevation. You can see it sitting in it's area but you just know how it looks like in 3D, and whether or not it fit. Especially with the software we've got, I use ArchiCAD, you can use the materials as well that you want. For example if you want metal steps, or if you want glass steps, you can create them. So when you render it, it looks quite realistic. So you can visualise it a bit more, especially if you are showing it to someone.

Frank: So does the choice of material influence how you design in the section? So if you had a metal staircase, would that change something around that as well?

Spencer: Yeah, I think so. For these materials, it would definitely... I think especially for my building. I want to be it quite like, I guess, classic Architecture... not Architecture, I mean, library style. Like wooden. Like you would imagine, quite nice... So having metal steps might not be the way forward, but if you had like stone steps, it would make it feel oldie again. But also then glass step, even though it makes it modern, also gives you that crystal like feeling. So it doesn't feel like it's taking up space because the light is kind of going through it. And it's fractured rather than just being solid metal. Also the sound would be like a lot different. If you are walking through on metal steps in a quiet library, whereas if it's on solid stone its that pad... It's quite enjoyable to think about these things, I guess.

Frank: Since material has such a big impact, how do you select it then? Do you go through your list and start with wood, then stone, then metal...

Spencer: Yeah, kind of. You do think about what I wanted with this building. And then where it's going. And then I kind of look at the material the building site currently uses. So for the external facade it would kind of be slightly related to what's round there already. So it doesn't stick out too much. Which does kind of limit me a bit. But then, if you don't want to be too outrageous, unless your building is already kind of bold. But won't mind to kind of fit in with my other team mates and class mates ideas as well. But then the internal structures are more about how I want the feeling. If you want to have a shiny new polished surface, feel like a hospital or something, then I would go for glass interior and thicknesses that feel kind of like it's clean and pristine and shiny floors. Where if wanted to have that oldie feeling, I would put some nice oak, wooden floor boards, or this beautiful kind of brown teak kind of bookshelf unit that goes quite around. And then large windows that let a huge amount of lights through. Kind of like this. It's quite fun. People would then feel that they are more connected than they already are. Which can happen with a lot of material. Concrete always makes you feel a bit more, I don't know... If you are between two big concrete walls, you feel a bit more enclosed. Whereas if its glass, you feel like you are free a bit more. Which is nice how material can make you feel like that, which is quite interesting.

Frank: You mentioned early in our conversation, that you are thinking about originality as well. Does that influence your choice of materials as well?

Spencer: I guess, originality definitely help with that. So if you...A library near where I used to live, that was like one of those county country council house libraries. It had those really thin cheap tin metal shelves which are grey as paint. It's useful, it's functional for what it's needed for... You can imagine that, but with... Imagine that in your house, that would be amazing. And how about having it in your own library, in the city that you live in and you could go to. I guess it's more of an idea for people who'd... I don't know. You'd love it to be that way. And whether or not it will be useful for you, but you'd definitely use it for the novelty. But having beautiful wooden shelves, that you could see were worn over time because people have used them, rather that metal where you can only see that the paint is gone and that's it... It's kind of more of a feel, more of a If I had a house it would probably just be wooden everything so it would felt more kind of homey... Beautiful like faux leather sofas that you can just sink into. Enjoyable and definitely comfy. Just to be reading a good book. Or if you are doing, like I said, scientific reports or an English novel then you gonna read some non-fiction. And you know that's all you came for. So you don't want to sit in a comfy chair because otherwise you might just be drifting off reading this boring essay or something. So you've gotta sit down at a hard chair at a hard surface and write. Or if you wanted, I don't know... For me, I split. I wrote out every genre of book that I knew. That I could think of from the top of my head. And put those in three different categories to create three different rooms.. I would usually draw them, but I wrote them out this time. It's not my usual method. But I wrote it down what I thought that each book room would create. For example, fiction books with series or novels or adventure books, all that kind of stuff. I put it into good-reads. So you would have a good-read room, which would have those sofas, coffee machines, and coffee tables. And they would have enough spaces, like personal spaces, big enough to wave around your arms and you wouldn't hit anyone. Then you had, I don't know, health books. So that's definitely kind of non-fictionally. It's all about improvement and stylizing your life about better health, better you, so self-help kind of books. You wouldn't want a comfy chair, but you wouldn't want a hard desk, either. Maybe it's more like an office desk the type you see at home. You can sit down, flip the lamp on... Could even try to take a few notes, but you wouldn't necessarily ... But you are enjoying it, you are doing this for yourself. That was another one. And then you've had the information books. You've had essay writing and stuff. And that was definitely kind of structured, maybe the way you were taught in school. That's what you wanted, what you came to the library for to do your research. Which is quite funny. If you go to libraries in America just with lines of wooden desks in strips and then lamps on each one, wooden chairs. And you would set up, sit down, and get your work done. But what you then have to think about is children as well. Would the children want to read those books and if so, would the adults want to have those noisy children around them? So creating pods, where the children could then go inside with the books from wherever they have been to. Sit down, and then they could read those books. Whether or not this was a novel, they had their own desk in the corner. So would be debatable what age groups they would be, maybe four to sixteen. Or twelve, maybe. And for the between zero and four, you'd have a play plan, where the parents could leave their kids.

Frank: So does this also come out of your observations on the site? Did you see kids there?

Spencer: Yeah. What we observed from the questionnaires was that a lot of parents and families would move though that space. They walked through that space. But they rarely just use it for anything other than just a gateway. A pathway to get somewhere else. So whether or not that change... There were a lot of people moving. Whether or not that would change through the library...Hopefully they will flow through there, then stop, then go in. Which would definitely be the aim any library there. Yeah, it's interesting. And hopefully the kids would be there for that reason to then use that space. I am not sure whether or not the parents would want their kids to be in the library and reading without their supervisions. And not having that supervision. They were safe inside the library. There isn't any way of them getting out there without them.

Frank: So you haven't really talked with any parents yet if they liked your idea?

Spencer: No. We only asked them question about how they use that space currently. We had quite some weird reactions, because I am quite a big person. So walking up to a family and ask them so: "Hey would you want to keep your kids safe if we had a library here?" and you see the parents pull their kids close and carry on walking. And I am like OK, that's fair, that's up to them. Even Hannah, who is that tiny little girl, she didn't have much luck talking to families. The parents are just like close tunnel vision, trying to get places... So we kind of left those off, didn't really care.

Frank: Do you talk to any of your non-Architect friends about your ideas?

Spencer: My parents. Yeah, a few friends who do ask. But it's not that many. We are not trying to talk about Architecture that much when we go out. So I don't want anyone else getting bored of what we are talking about. Which is sad, but that's the reason we chose this and they didn't, I guess.

Frank: But your parents enjoy those talks?

Spencer: My mum and dad love it. My dad is... My parents are very creative. My dad is trained as an estate manager, he has been doing it for forty years, and he can build, design a house. He can do the electrical, all the plumbing himself. Give him a project and he'll do it by himself. Whereas my mum... She is definitely more the arty one in the family. Very practical. She is a seamstress. So she does all the sewing and making. She is very good. She loves learning. She is definitely someone... If I start talking with her about my project, she'll definitely go "Oh yeah, I love this. I have recently read a book that has something to do with this." And then she'll have a deep discussion about, I don't know... And she'll say I saw this Facebook post or I saw this building... And then she will have some way or methodology to discuss it. And she will have ideas and will just send me these notes that she'd have. And then I'd discuss my building and she will go Oh yeah, do you remember... and then we'll have another discussion about a building she saw and that was related and that was related to my building. Which is quite fun for me. I am one of six children. So my older siblings are all very kind of arty. She basically has like six university degrees after helping all of us out. So that's the fun for her. For me that's quite nice to have a parent like that to discuss Architecture. She does enjoy listening to what I am saying. And then feeds off, and bounces ideas back and forth.

Frank: Does that happen a lot in your group as well? Do you have a lot of group discussions?

Spencer: Yeah, there is quite a lot of group discussion. It's more, it's more about... Especially in the beginning it's more like... I think people are trying to make themselves understand, where everyone else is situated. We knew each other as friends, but we didn't know where each other's ideas were individually. And then I think it has taken some time. People have worked around each other's ideas. And some kind of backlash between a could in the team which has been interesting to see how they developed their ideas over that clash. But then came back and worked on it even harder.

Frank: So do you think working in that group helps or rather hinders you getting to your goal?

Spencer: That depends. Me personally, if it was a time based, project, which it is, I'd definitely say working in teams makes it easier as long as you know the team you are working with and you know what their goals are. I am quite happy to work with whoever I've got. Because if I have ideas, I'm quite happy to bounce them off. And if I get stuck down on one idea... So this morning I've changed an idea that I've had for two weeks.

Frank: So how did that happen?

Spencer: I had an original design that linked in with Hannah's project. The bank, down at the site, has this kind of curve. She was trying to bring that around so I did as well but that made mine a cylinder. And from that cylinder it also went to the room outside this lobby, this lounge area, that's situated to look over the rest of the site. There was still this kind of cylinder idea. It was OK. It was quite standard. If you'd been in the middle, it would have looked quite cool. If you turn around and have those books if you'd imagine it. It was sunk into the ground as well. So it was six foot high and three below... But then I didn't know why I carried on with the curve on the side and the front. It just didn't seem to fit. It kind of felt like the back end of what it was up against, the car park. So it was kind of... I had though about everything on the interior, and everything kind of worked. But outside, on the sections, like on this one, kind of felt like you get pulled in by this curve and then you get stuck between the current half the car park to the left and this wedge that I created. So there was just dead space here. And then the rest of the curve just kind of left it. It felt like it could have taken you somewhere, but it really wasn't. So kind of instead of that I wanted this open space, which was quite public. Thinking about how I wanted to cut the public and wanted to bring their focus of attention to to the entry way. They could see the interior. It might have take more of a journey to go into that area. Because it was concave, it would bring them in. Because it was covered by the car park, bring the sink of the car park lower. So that you get all the light from the south facing area shining though. It would have been quite dark, so there would have been unnatural light, which would have been quite sad, especially for such a nice building. But that took some change, I am not developing that again. I could see from the 3D modelling, that it would not have worked.

Frank: How did you decide it would not work?

Spencer: I guess it is from the training, but it's definitely a feeling for me. This part I haven't really thought about it, haven't thought about how it would situate itself. The reason why I left the dead space, and I didn't have a reason. I had chosen the form, but I hadn't really thought about the space I left behind. So that's in Architecture it's not just about the space you create, it's also the space haven't used. Leaving a dead space like that was kind of null. Not really useful for anyone. Was just kind of pointless, and would have left me as if I had failed. I guess, you can't think of everything, but if you think about something and there is no reason to keep it... I mean it was just itching, I had to change it.

Frank: So would you say that training for Architects is also about feelings and emotions, so maybe there are some hidden properties of the trait?

Spencer: Yeah. It is definitely the effect of the training over the year. Of what I have learned and read and what I have seen of Architects themselves. There is an Architect that designed a church and he thought about absolutely everything. I have forgotten his name, it's in Sweden. And it's a really beautiful church. But it's basically... He didn't cut any brick, whatsoever. The entire... The only thing he added, he sliced off a few faces in the front so that the priest wouldn't get caught on the rough surfaces. Everything was beautifully aligned and thought about. Up to the fact that the windows, the light... From what people told and what the bible said, Jesus Christ died at 3.30 or 3.15 or something. And the sunlight shown through at this time would shine on his name and the date of the building being built. I mean, to think about that. To have that idea of people having to notice that years later after he is gone and how every brick... It's just a phenomenal building, to be honest. I am not religious, so it's not for me, but I can definitely appreciate going there. He just did think of everything. The brick cut sizes, how everything had to be oriented. To create that space that was so phenomenal. And like a water flowing area that had this little arch way...

Frank: Is that your ideal as well, is that what you want to be in 10 years? One of these Architects that thinks of everything?

Spencer: I'd love to be able to think about everything, every little detail, and obviously, if you got time, then you could. Depends whether or not it would be useful to think about everything. But there is even stuff I have noticed with my dead. He is not a famous Architect, in fact he is not a trained Architect, but he can design and draw. He did all the drawings for the current house that we are living in. Stuff that he built, this beautiful oak beams for our roof, which he built three years ago and we put in last summer. He built them to the exact specifications he worked out. Drilled the holes and everything. I only realised now, that we are doing the interior, another year later or so, we started doing all the electrics and all the lighting. And he drilled in holes in the beams, which you can't drill in right now because there is no space and the drill bit would need to be like this, there is a hole through all the beam to hold al the electrics. He did that three four years ago for things that we are doing now. That just took me back a little, I was quite impressed by that.

Frank: So if you are thinking ahead, is there something you are working towards for the next year?

Spencer: For this I chose RDV, because I wanted to improve my thought processes. The tutor is an Architect rather than someone who could just rely on technology. I am quite technology based. I am young enough to just turn on the computer and know how to use programs. And if I don't know there is YouTube and I can work it out. So from there I just didn't want to follow through and do easy stuff. I want to be able to think about my design a bit more, have a thought process, use paper, and do draw sections by hand. For me the RDV was more kind of interesting.

Frank: So why is this hand drawing and paper thing important?

Spencer: Because for me it's different from using computers. You can have more of flow with pen and paper. You can just draw a line and if you get it wrong rub it out and start again. It's never gonna be the same ever again. While on the computer you can undo it and do the line exactly where it needs to go. So it's a bit more classical, more interesting, I guess.

Frank: But doesn't that introduce a lot of errors?

Spencer: Yeah, a lot of errors and a lot of faults. But that's part of the process. Whether or not those errors were actual error or you want to keep them, or if they were quirky or you might want to make them more quirky...

Frank: Did you find quirks during the current project?

Spencer: Yeah, with the design I just scrubbed I found the cylindrical sphere having stairs to the centre. But then I though about what when I did them just in right angles? And it would have been funny, if you looked down the staircase, nothing would have fitted together. An odd shape to look down onto. The broken up light would have made people feel like they weren't going in the same direction. Or at the back. I am trying to bring the people from behind the building back around to the front. But I want to do that without splitting them of. So creating maybe some unique patterns on the floor.

Frank: OK, then thank you.

2 Publication record

Peer reviewed publications

Kristensen, M. S., Loesche, F., & Maranan, D. S. (2017, November 21). Navigating Cognitive Innovation. *AVANT*, *8*, 45–55. doi:10.26913/80s02017.0111.0005.

Loesche, F., Goslin, J., & Bugmann, G. (2018, October). Paving the Way to Eureka — Introducing "Dira" as an Experimental Paradigm to Observe the Process of Creative Problem Solving. *Frontiers in Psychology*, *9*. doi:10.3389/fpsyg.2018.01773.

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frontiers in Psychology

ORIGINAL RESEARCH
published: 02 October 2018
doi: 10.3389/fpsyg.2018.01773

Paving the Way to Eureka—Introducing "Dira" as an Experimental Paradigm to Observe the Process of Creative Problem Solving

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"Dira" is a novel experimental paradigm to record combinations of behavioral and metacognitive measures for the creative process. This task allows assessing chronological and chronometric aspects of the creative process directly and without a detour through creative products or proxy phenomena. In a study with 124 participants we show that (a) people spend more time attending to selected vs. rejected potential solutions, (b) there is a clear connection between behavioral patterns and self-reported measures, (c) the reported intensity of Eureka experiences is a function of interaction time with potential solutions, and (d) experiences of emerging solutions can happen immediately after engaging with a problem, before participants explore all potential solutions. The conducted study exemplifies how "Dira" can be used as an instrument to narrow down the moment when solutions emerge. We conclude that the "Dira" experiment is paving the way to study the process, as opposed to the product, of creative problem solving.

Keywords: creative problem solving, divergent thinking, convergent thinking, behavioral experimental paradigm, chronometric temporal measures, insight, chronology

OPEN ACCESS

Edited by:
Philip A. Fine,
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Specialty section:
This article was submitted to Cognition, a section of the journal Frontiers in Psychology

Received: *30 March 2018*
Accepted: *03 September 2018*
Published: *02 October 2018*

Citation:
Loesche F, Goslin J and Bugmann G (2018) Paving the Way to Eureka—Introducing "Dira" as an Experimental Paradigm to Observe the Process of Creative Problem Solving. Front. Psychol. 9:1773. doi: 10.3389/fpsyg.2018.01773

1. INTRODUCTION

Creativity (Runco and Acar, 2012), innovation (Amabile, 1988), and problem solving (Newell and Simon, 1972) have shaped human history, culture, and technology. Valued by today's society for their contributions to education, recruiting, and employment (Cropley, 2016) they are also likely to play an essential role in our future society. Moreover, creativity, innovation, and problem solving are required to address the increasingly complex problems we are facing. A commonality between these phenomena is the aim of identifying novel and useful answers to more or less well-defined and ill-defined questions (Simon, 1973; Weisberg, 2006). Based on observations and reports from eminent scientists such as Helmholtz and Poincaré, Wallas (1926) famously suggested that the process of generating answers or creative products consists of several consecutive phases. Since then the exact structure and number of these stages are being debated (Amabile, 1983; Finke, 1996; Csikszentmihalyi, 2009; Amabile and Pratt, 2016), but arguably, the moment when a solution emerges lies at the heart of the matter. This "illumination" phase often follows and precedes other stages (Howard et al., 2008): Before finding the solution, the problem solver needs to "prepare" for the problem at hand, for example by understanding the question, potentially within the larger context. If people do not solve the problem in this phase, they might enter a stage of "incubation." In this stage, they are thought to unconsciously keep processing the problem while they consciously attend to other tasks. The feeling of manifesting associations or fringe consciousness coined as "intimation" is the next stage in this model (Sadler-Smith, 2015). Following this, the problem solvers experience a phase of "illumination" when they suddenly have an idea that answers the question. Afterwards, during the "verification" stage, this solution is tested. Certain models consider additional stages to communicate and implement a found solution as part of the process. Csikszentmihalyi (2009), for example, calls it the "elaboration" stage. To sum up, within existing case studies of creativity, innovation, and problem solving and the theories behind them, the moment when solutions emerge is part of a longer "creative process." However, most studies focused on the outcome of these three phenomena, without considering the various processes behind them.

Previous studies identify the moment when solutions emerge through a range of different phenomena (Kounios and Beeman, 2014), for example restructuring the problem representation (Knoblich et al., 1999; Fleck and Weisberg, 2004), an alteration of mood (Baas et al., 2008; Subramaniam et al., 2009), and the suddenness of changes (Topolinski and Reber, 2010a). Reports of these potentially associated phenomena have been used as markers of "insights," "Aha! moments," and "Eureka experiences." However, some of these phenomena might only be weak proxies. Danek et al. (2016) have shown that not every solved problem relies on restructuring. In a follow-up study, Danek and Wiley (2017) revealed that not every experience of insight results in a solved problem. Even if a link between observed phenomenon and "Eureka experience" is well established as for the mood change, the chronology or even causality remains unclear: Does insight increase mood (Akbari Chermahini and Hommel, 2012), does a stimulated positive mood cause "Aha! moments" (Isen et al., 1987; Ritter and Ferguson, 2017), or are they both results of another process? Therefore, there is a need to detect emerging solutions directly and not via proxy phenomena. Moreover, most studies on insight assume Eureka experiences are dichotomous, "Aha! moments" either suddenly happen or not (Bowden and Jung-Beeman, 2003; Gilhooly and Murphy, 2005; Subramaniam et al., 2009; Hedne et al., 2016). Possibly the phenomenon benefits from a more differential view, theoretically and empirically.

In this paper, we introduce "Dira" as a novel experimental paradigm to narrow down the moments of emerging solutions within the creative process. In each of the forty "Dira" tasks, participants are asked to find a solution. A solution is the image they consider to correspond best with a one-line text. On a computer display, the on-screen text and images appear blurred by default and can only be seen clearly when the mouse hovers above them (see **Figure 1**). Tracing the mouse movement and the hover time on each image allows to measure the time participants spend processing an image during task execution and before they report a solution. After each task participants provide metacognitive self-reports, such as the intensity of their Eureka experience that accompanies emerging solutions (Cushen and Wiley, 2012; Danek et al., 2014). We hypothesize that the combination of behavioral measures of the process and self-reports can be used to identify distinctive behaviors when solutions emerge and localize the solutions' emergence in time. Further, we hypothesize that feedback on the participants' choice moderates the behavior and the reported Eureka experience thereafter.

2. RATIONALE

In this section, we summarize existing tasks that have been used to observe the moment solutions emerge during creative problem solving and we provide an argument for a novel experimental paradigm. We describe the origin of "Dira" and how we acquired the problems participants are asked to solve. Finally, we argue for the mouse-tracking method to trace people's problem solving process.

2.1. Existing Tasks Related to Emerging Solutions

Different types of tasks have traditionally been associated with the creative process and emerging solutions, namely insight tasks, divergent thinking tasks, and convergent thinking tasks.

From a historical perspective, insight tasks (Maier, 1930; Duncker, 1963; Gardner, 1978; MacGregor et al., 2001) are the oldest of these types of tasks. They predate the distinction between divergent and convergent production as introduced by Guilford (1967) and were consequently developed without a direct reference to one of these processes. These insight tasks often take the form of riddles or visual puzzles and are built around the assumption that the task itself requires restructuring (Knoblich et al., 1999; Fleck and Weisberg, 2004). The overlap between insight tasks and convergent thinking tasks seem particularly strong: for example, Bowden and Jung-Beeman (2003) argue, that convergent thinking problems like the Remote Associate Task share properties with insight tasks. Nevertheless, convergent thinking tasks can either be solved via insight or without. Similarly, classical insight problems are often thought to converge to a single solution, even though examples for the nine-dot problem show that more than one solution is possible (Maier, 1930; Sarcone, 2014). Furthermore, and as Bowden et al. (2005) and Danek et al. (2016) demonstrate, finding solutions to insight tasks does not require insight or an Aha experience. While timing has been discussed since the earliest studies on insight tasks, often it only relates to the time when a solution is found. These type of tasks are not repeatable and allow only between-subject comparisons. Even more, having solved similar problems in the past seems to influence the process (Lung and Dominowski, 1985), and it is difficult to identify the similarity between problems as well as to control for previous exposure. Consequently, the classic insight problems are not considered for this study.

FIGURE 1 | Example of the screen during a "quiz" **(Left)**, all elements unblurred **(Center)**, and the color coded positions **(Right)**. The center and right subfigure show an example mouse movement. The mouse positions at onset and offset times t_1 to t_7 are recorded as raw data. The figure on the right shows assigned symbolic names and colors for each position "a"–"f" and "story" (text) as used in later plots. The text was initially inspired by the image with the white circle, because in "image c" the shadow reveals the true intention of the figures in the foreground. The black circle marks an example of a "chosen solution". Dixit images by Libellud.

Divergent thinking tasks (Torrance, 1966; Guilford, 1967; Runco et al., 2016), in which people are asked to generate several potential solutions to a question, are associated with individual creative processes. Nevertheless, the measurement of originality is usually assessed within the cohort of the experiment and not for an isolated individual. Consider a "Brick Uses" task (Wilson et al., 1954; Guilford, 1967, p. 143) in which participants are asked for alternative uses of a brick. An answer to use the brick's pigments to paint might be unique within an experiment, but the participant might just have reported an instance from memory (Gilhooly et al., 2007; Hass, 2017). Hence this solution, although original within the experiment, did not require creative problem solving from this particular individual. Furthermore, before assessing the originality, raters decide if answers are considered for the scoring. For the answer "to paint" in a "Brick Uses" task, which is similar to the previous example, some would consider it an "impossible answer" and consequently remove the answer before scoring originality. Time measurements are often provided by a minimum or maximum task time and through fluency measures, and recently the moments of the production of a solution have received more attention (Forthmann et al., 2017). Divergent thinking tasks are in general repeatable, but the difficulty in scoring, and the unknown origin of the solution, either from memory or as a novel product, disqualify these types of tasks for our purpose.

Finally, Convergent thinking tasks (Mednick, 1962; Knoblich et al., 1999; Bowden and Jung-Beeman, 2003), require participants to come up with a single solution. These tasks are based on the difficulty to search a large problem space, produce interim solutions, and verify these results. Some of these tasks, such as the Compound Remote Associates test, were developed to specifically address the shortcomings of the classical insight tasks (Bowden and Jung-Beeman, 2003). Convergent thinking tasks typically provide a large number of stimuli for repeated measures. For word-based convergent thinking problems, language fluency affects the ability to solve the problem (Hommel et al., 2011).

In our study, we intended to observe behavior during the creative process, but for problems with three verbal stimuli such as the Compound Remote Associate task, prospective problem solvers might not exhibit much observable behavior. The low number of word-based stimuli within a single task (typically three) are easy to memorize, and participants can operate entirely on their working memory. There is little incentive to reread the words or exhibit other behavioral cues through which the internal thought process could be traced. The timing of the solution and the success within a given time are central measurements in this type of task. For example, Salvi et al. (2016) ask their participants to press a button as soon as they found a solution. This timing relates only to the whole process but does not allow the identification of the involved sub-stages. Therefore we decided not to use convergent thinking tasks to trace the emerging solution within the creative problem solving process.

2.2. Development of "Dira"

"Dira" has been developed out of the necessity to collect fine-grained measurements of the creative process. As an experimental paradigm to observe the moment when solutions emerge, "Dira" needs to address one fundamental requirement: the solution should not be known from the beginning. In this sense, a solution could either be the answer itself or an algorithm how to arrive at the answer. If either was known at the moment the task was given, "Dira" would merely provide measures related to other processes, for example processing fluency and memory retrieval.

"Dira" is inspired by "Dixit," a commercially available and internationally acclaimed card game. The word "Dixit" is Latin for "he or she said," chosen by the French developers of the game, supposedly to highlight the story-telling aspect. We use the French word "Dira" for "he or she will point out" as a reference to the process throughout the task as well as the origin of the inspiring game. The 84 unique images of a "Dixit" card deck are described as "artwork"[1] and "dreamlike"[2] and have previously been used in teaching a foreign language (Cimermanová, 2014), in research on imaginative design narratives (Berger and Pain, 2017), and observing conformity and trust between humans and robots (Salomons et al., 2018). The cards have also inspired interventions to foster creativity (Liapis et al., 2015), and are suggested as "an additional source of inspiration" (Wetzel et al., 2017, p. 206) for an ideation method.

The task "Dira" we developed uses elements and data from the game "Dixit." Therefore, we briefly introduce some relevant aspects of the game. Three to six players can participate in the "Dixit" game, which is played in several rounds. At the beginning of a round, one of the players is appointed as the storyteller. From the deck of 84 unique cards with beautifully drawn images, each player receives six cards in their hand. Based on the drawing on one of the cards, the storyteller invents a short text and tells it to the other players. Related to this text, all other players select one card from their hand. The selected cards are shuffled and played on the table. Now all players except the storyteller have to guess which of the images originally inspired the text. Based on their choice, the storyteller and all other players receive points. Hereby the scoring system penalizes storyteller that produce descriptive texts and associations that are easy to find. Furthermore it encourages the others to play cards with a similar non-obvious connection to the text. Moreover, and based on the different associations the players formed, each image has some connection to the text. At the end of a round, a group of players has produced a combination of a short text and as many associated images as there are players. Nevertheless, and as the example in **Figure 1** illustrates, it would defy the purpose of the game if the other players would immediately understand any of these connections.

In each "Dira" task we ask people to find a connection between a short text and one of six images sampled from past "Dixit" games with six players. As argued before, people are unlikely to identify the image that inspired the text immediately. Instead, they might find a connection between the text and one of the six potential solutions through controlled processes in creative cognition (Beaty and Silvia, 2012; Silvia et al., 2013) or unconscious associations (Mednick, 1962; Kenett et al., 2014). In the first case, participants generate several metaphors or potential solutions from available information and select one of them as the best fit at a specific time. In the second case, existing associations are mediated through similarities of common elements before one of them is identified as the best match. In both cases, the solution emerges at a distinct moment before participants select one image by a mouse click. Participants in the "Dira" task are forced to make a choice, but which of the six possible solutions they choose depends on their prior knowledge and their subjective understanding of the task at hand. These differences in problem difficulty are described for other problems as well. Often, the correctness of a task solution is considered vital to the measures and consequently needs to be controlled for, as Öllinger et al. (2014) demonstrate for a well know 9-dot problem. "Dira" does not have one objectively correct solution and we are not interested in the exact timing of finding the subjectively correct solution. Instead, we assess the behavior during the process through the interaction times with text and images.

For the developed task we assume that two different modalities for the stimuli are advantageous to isolate remote conceptual associations. If the two stimuli that were to be matched used the same modality, matches could be found for aspects of these stimuli that are outside the interest of this study. For example matches between two visual stimuli could not only be based on the depicted content, but also on colors, forms, and dynamics of the image. For two verbal stimuli the constructing syllables, cultural connotations, and language fluency of the problem solver would play a decisive role in the selection of an answer. By asking people to match content from different modalities, we hope to circumvent the issues above.

2.3. Dataset

The experience of an emerging solution relies on the inherent quality of the task; in the case of "Dira" on the text as well as on each of the potentially associated images. Instead of constructing a synthetic dataset, we crowdsourced the combination of a single text and six accompanying images from a community of experienced "Dixit" players. Usually, the card game "Dixit" is played locally around a table. For groups not sharing the same space, Boite-a-jeux[3] provides an online gaming platform to play this game across distances and with other players of a similar skill level. In August 2014 we accessed the publicly available recorded game data of 115,213 rounds of "Dixit." We filtered this initial dataset for English rounds with six players. After stopword removal (such as "the," "is," "at") and word stemming, we removed the rounds with stories containing the most frequent words from the 90th percentile. Looking at the text and images, candidate sets for the "Dira" task were selected from the remaining 1,000 rounds of recorded "Dixit" games. The authors of this paper, two of which are experienced "Dixit" players, chose 40 combinations of text and images. Afterwards, we identified between one and three contexts of associated knowledge to control for participants' domain-specific knowledge in a later analysis. For example, the sentence "Standing on the shoulders of giants" is meaningful in different domains like the scientific community exposed to life and work of Newton, but also for fans of the Britpop group "Oasis," who released an album with the same name. The identified contexts were then grouped into the following eight clusters (with the number of associated stories in brackets): Literature (8), music (6), film (7), science (7), popular culture (12), and high culture (7) as well as word games (11), and literal interpretations of visual cues (10). These contexts allow to control for required knowledge to solve the tasks. Finally, the order of the tasks within the "Dira" experiment was initially

[1] Dixit publisher's website http://en.libellud.com/games/dixit, last access: 2018-02-23.

[2] Wikipedia: Dixit (card game) https://en.wikipedia.org/w/index.php?title=Dixit_(card_game)&oldid=823435686, last access: 2018-04-05.

[3] http://boiteajeux.net; last access 2017-11-15.

chosen at random but kept the same throughout all conditions reported in this paper.

2.4. Mouse-Tracking as Process-Tracing

"Dira" is based on the fundamental assumption that psychological processes can be traced through observable behavior (Skinner, 1984). Of particular interest to the emerging solutions is the participants' behavior during the task when they are engaged in a creative problem solving process. At the beginning of each task, participants do not know the text or the images. To solve the problem, they have to acquire information from these elements and find associations between the text and the images. For "Dira" the process of information acquisition is related to the order and timing of interactions with each of the elements on the "quiz" screen. Different methods are commonly used to trace these chronology and chronometric measures of processes, for example through verbal protocols (Newell and Simon, 1972), eye-tracking (Thomas and Lleras, 2007), and mouse-tracking (Freeman and Ambady, 2010).

Verbal and think-aloud protocols have been used in insight tasks (Fleck and Weisberg, 2004), divergent thinking tasks (Gilhooly et al., 2007), convergent thinking tasks (Cranford and Moss, 2012), and also in real-world problem solving (Newell and Simon, 1972; Kozbelt et al., 2015). While Schooler et al. (1993) identified an overshadowing effect for insight problem solving, Gilhooly et al. (2007) did not find any effect on fluency and novelty production in a divergent thinking task. In a meta-study, Fox et al. (2011) did not see an effect of verbalization on the results of tasks, but they noted an increase in the time required. These results suggest that think-aloud protocols might or might not change the solutions provided for a task, but they most certainly change the process. With our interest in narrowing down the time of emerging solutions within a process, verbal protocols seemed too invasive and were disregarded.

In a direct comparison between eye-tracking and mouse-tracking, Lohse and Johnson (1996, p. 37) conclude that mouse interactions "predispose people to use a more systematic search and process more information than they normally would." Similar to the technique described by Ullrich et al. (2003), elements in the "quiz" of "Dira" that are not directly under the mouse pointer are blurred. These indistinct images prevent participants from accessing this information without moving the mouse pointer to an element. A notable difference to the method developed by Ullrich et al. (2003) is that elements in "Dira" do not fade over time; elements are visible for the whole time the mouse pointer hovers over them. Uncovered images imply that information acquisition and information processing is possible throughout the whole hover time. Indeed, participants will not necessarily direct their full attention to the currently unblurred text or image. While this appears as a disadvantage of mouse-tracking, Ferreira et al. (2008) have observed the same issue for eye-tracking. People are also known to not always perceive visual input when generating ideas (Walcher et al., 2017). Furthermore, other processes such as memory access are related to eye movements as well (Johansson and Johansson, 2013; Scholz et al., 2015). Nevertheless, Freeman and Ambady (2010) have shown that mouse-tracking provides reliable insight into mental processes and while it provides more robust measures than eye-tracking, it is also easier to administer. Mouse-tracking was chosen as the process-tracing method for the "Dira" task, also because it allows running several studies in parallel in a non-invasive setup using standard hardware participants are familiar with.

3. METHODS

3.1. Experimental Design and Conditions

The computer-based experiment "Dira" is programmed as a series of different screens. From the participants' perspective, "Dira" combines perceived freedom to explore the task with aesthetically pleasant stimuli. Participants interact with the text and images of the task by hovering the mouse pointer over these elements. The order and duration of these interactions are up to the prospective problem solvers. The images are taken from the "Dixit" card game which has been praised for its artistic and beautiful drawings. Moreover, the whole experiment is designed like a game. These design choices are intended to make the "Dira" tasks "inherently interesting or enjoyable," one of the critical elements that are known to increase intrinsic motivation in participants (Ryan and Deci, 2000, p. 55). In turn, Baas et al. (2008) and da Costa et al. (2015) have shown positive correlations between intrinsic motivation and performance in creative problem solving tasks.

For the current study, "Dira" was administered in three different between-subject conditions. In condition 1 "Dira" does not provide any feedback and participants have no reference to evaluate their answers and performance in the task. In condition 2 we added a potential solution to trigger extrinsic insights. Given that tasks are often perceived as difficult, this demonstrates a possible solution to the participants and hence is thought to increase the motivation to solve the next problem. Furthermore, these solutions have the potential of triggering extrinsic insights, which are a special type of insight following the recent argument by Rothmaler et al. (2017). Given the correlation between mood and insight (Subramaniam et al., 2009; Akbari Chermahini and Hommel, 2012) a triggered Eureka experience could have a positive effect on the intrinsic motivation and metacognition. In condition 2 we want to explore if this leads to a change in the reported experience and observed behavior. In condition 3 we ask participants to elaborate on their reported solution. We expect this verbalization of an answer to increase the metacognitive awareness during task execution (Hedne et al., 2016) and hence an effect on "quiz time" and reported Eureka experience. Condition 1 was the first to be run and all participants at the time followed the same protocol. Subsequent participants at a later time were randomly assigned to either condition 2 or condition 3.

In condition 2 the additional screen "explanation" is added to each round as illustrated in **Figure 2**. Appended after the "rating," it is the last screen before the start of the next round. The "explanation" screen shows the "intended solution," the image that initially inspired the storyteller to invent the text. We also show a short explanation on how the intended solution and text are connected. The short sentence is based on a text taken from

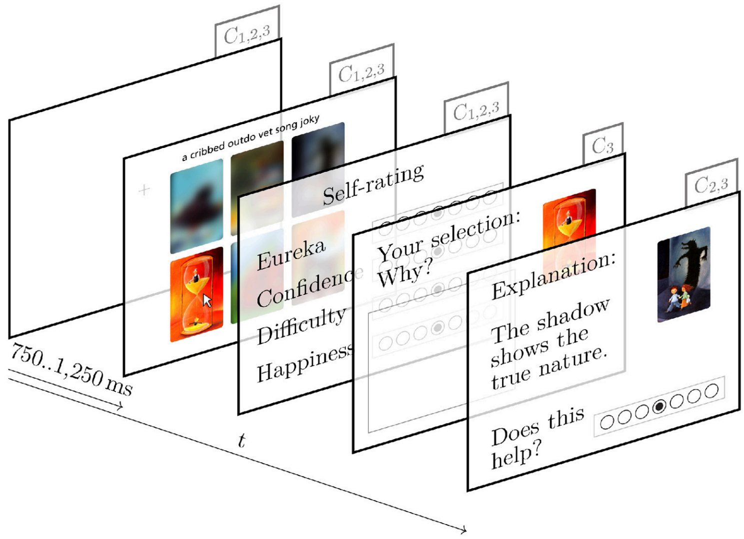

FIGURE 2 | Experimental conditions of the "Dira" rounds. Each parallelogram represents a screen and the annotation in the right upper corner identifies in which condition the screens are used.

the stimulus dataset and is designed to help the participants: One method to solve a "Dira" task is to empathize with the storyteller and find the intended solution that initially inspired the text. To assess the success of this help, we then ask the participants to rate "How much does the Explanation help [you] to understand the association between image and text?" Their answer ranges from "not at all" to "very much" on a seven-point Likert item. Submitting the answer starts the next round of condition 2 with a "fixation cross."

In condition 3 an "elaboration" screen is placed between the "rating" and the "explanation" screen as shown in **Figure 2**. In this screen, participants see the given text and their selected image, and they are asked to elaborate on their decision. Afterwards, they see the same "explanation" screen as described above. Once they have completed these additional screens, participants restart the next "round" of condition 3 with a "fixation cross."

3.2. Procedure

Any "Dira" experiment starts with an opening sequence consisting of a "welcome" screen, a "questionnaire," and a "description" of the task. This initial series is followed by 40 rounds containing a "fixation cross," "quiz," "rating," and optional "explanation" or "elaboration" screens. The experiment concludes with an on-screen "debrief."

A "welcome" screen explains the basic idea of the study as well as potential risks and the right to withdraw data. The study only continues if participants understand and agree to the minimum requirements that have been cleared by the Faculty of Health and Human Sciences Ethics Committee at Plymouth University. Once participants have given their consent, they are shown the "questionnaire."

During the "questionnaire" participants are asked to specify their age, gender and primary language and if they have participated in the study "Dira" before. They are also asked to rate their fluency in understanding written English and familiarity with the card game "Dixit" on a seven-point Likert item. Participants are also asked to rate themselves in 14 additional seven-point Likert item questions, four of which belong to the Subjective Happiness Scale (SHS) developed by Lyubomirsky and Lepper (1999) and ten more of the Curiosity and Exploration Inventory II (CEI-II) as published by Kashdan et al. (2009). The scales were chosen because emotional states (Baas et al., 2008), openness to experience, and intrinsic motivation (Eccles and Wigfield, 2002) are known to influence problem solving (Beaty et al., 2014). These results are not discussed here since the interaction between individual differences and the performance in the "Dira" task are beyond the scope of the current article.

Once participants have completed the questionnaire, the procedure of the experiment is explained to them in detail in a "description" screen. This screen also holds a minimal and neo-Gestalt inspired definition of the "Eureka moment" as "the common human experience of suddenly understanding a previously incomprehensible problem or concept," for accessibility reasons taken from Wikipedia (2016). Afterwards, the 40 "rounds" of the experiment begin.

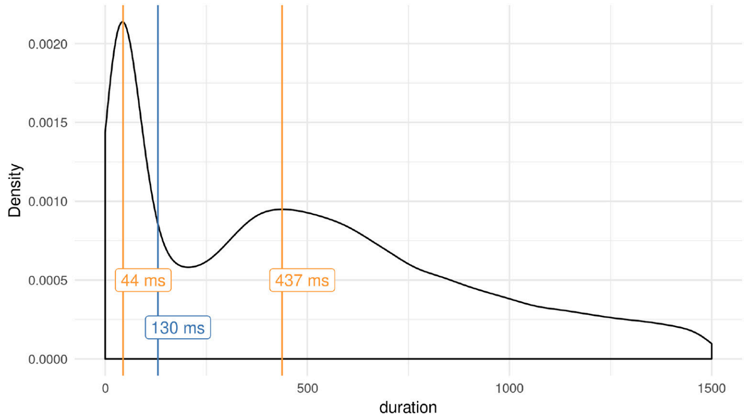

FIGURE 3 | Distribution of hovering times on elements during the "quiz." The modes of the bimodal distribution are marked with red lines. The cutoff time between the two distributions, a result of the classification described in the text, is shown in blue.

Each "round" starts with a "fixation cross" which is shown at the center of the screen for a randomized time between 750 and 1,250 ms. Afterwards text and images appear on the "quiz" screen as illustrated in **Figure 1**: one text on top and six images in a grid of two rows by three columns. Unless the participants hover the mouse on top of these elements, the letters of the text are shown in a randomized order, and the images are strongly blurred. An example can be seen in the second screen of **Figure 2** which shows the text "Don't judge a book by its cover" with the letters in a randomized order and images blurred except for "image f" over which the mouse pointer hovers. The recording of hover times during the "quiz" allows to track when participants pay attention to each of the elements and for how long (Navalpakkam and Churchill, 2012). On this screen, participants attempt to find the image that they think is most likely associated with the text and select it through a single click. There is no time limit for completing this task. Once participants have chosen a solution, they advance to the "rating" screen.

During the "rating" screen, participants are asked to rate their performance in the "quiz." They are asked the following four questions, with the range of possible responses on seven-point Likert items in brackets: "How confident are you that the solution is right?" (not confident—very confident), "How hard was it for you to come up with the solution?" (not hard—very hard), "How strong did you experience a Eureka moment?" (not at all—very strong), and "How happy are you with your answer?" (very unhappy—very happy). After submitting the answers, the next round starts with a "fixation cross."

Participants who have completed the 40 rounds conclude their participation with the "debrief" screen. Here they are informed that the study intended to measure the timing of their behavior during the "quiz." Participants are encouraged to give additional feedback concerning the experiment, and they have the option to leave an email address in case they want to be informed of the results of the study. This on-screen debrief was followed by a short unstructured personal discussion relating to their experience in the Dira experiment.

3.3. Task Administration

The controlled study "Dira" was designed as a computer-based task administered in a laboratory setup. The task was delivered through a custom developed web application delivered through a full-screen web browser. The same type of computer mouse with an optical sensor and the same type of 22 inch LCD screen with 1,920 × 1,080 pixel resolution were used for the whole experiment. Participants are most likely familiar with the setup as it is the same hardware available to students in library and public computing spaces across campus. The experiment was delivered in a dedicated room with no more than five participants at the same time who were asked to stay silent during the experiment. Welcome and debrief was performed outside the room to keep any distraction to a minimum. Informed consent was collected from participants; then they were accommodated at a computer showing a "welcome" screen.

3.4. Participants

One hundred and twenty-four participants between the age of 18 and 56 ($\overline{age} = 22.6$, $sd = 6.99$) were recruited from a local pool of pre-registered psychology students and a second pool that was open to students of other courses and members of the public. While two of the participants chose not to report their gender, 83 identified as female and 39 as male. Psychology students received course credits and points for running their studies. Participants from the second pool received monetary compensation. The overall sample appears similar to the one described by Henrich et al. (2010).

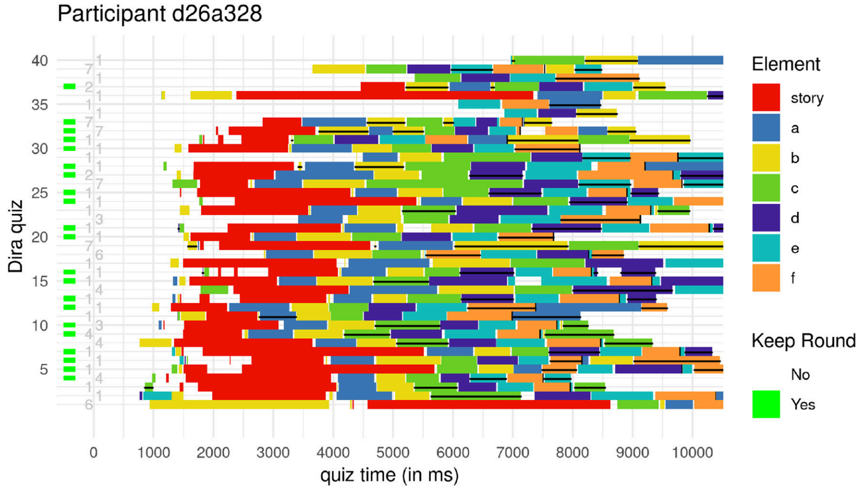

FIGURE 4 | One participant's interaction with text and images during the first 10 s (x-axis) of each of the 40 rounds (y-axis). The length of each colored bar notifies the duration, the color identifies the position of the element. Horizontal black lines mark the items that are selected in this round, the vertical black lines mark the end of the "First Full Scan." The numbers between one and seven next to the y-axis show the reported strength of the Eureka experience for that round. The green blocks mark rounds that are kept for further analysis. For details see text.

3.5. Data Pre-processing

The data collected during the "quiz" of the "Dira" task are intended to trace the participants' thought process through their behavior. The recorded dataset includes chronological information concerning the order in which participants engage with elements, as well as the duration of the interactions.

The chronology or order in which participants engage with elements shows that they do not interact with all elements in each round. If participants do not look at the text, this has implications on their ability to solve the problem: Participants who have not seen the text will not be able to find an association between the text and one of the images for this particular round. On the other hand, if they have seen the text but not all images, they are still able to find a solution. Rounds in which participants did not look at the text were therefore excluded from further analysis, whereas rounds with missing interactions for some images were still analyzed. Furthermore, cognitive processes deployed in rounds that start with the text might differ from the ones starting with one of the images. To control for these different modalities, we focus in this paper on the rounds starting with text and remove all others.

The duration of interactions with text and images is assumed to relate to the amount of acquired and processed information. However, the data also include quick movements that do not contribute to acquiring information, as illustrated in **Figure 3**. If people want to look at an element not adjacent to the current mouse position, they need to move the pointer across one or more elements. In this case, the distance of the mouse pointer from the target image is between 1.5 times and 4.3 times the size of the target. According to Fitts' law, the task of moving to a distant image has an index of difficulty between 1.3 and 2.4. Applying the extreme values for throughput suggested in Soukoreff and MacKenzie (2004), participants are estimated to require between 260 and 640 ms for the whole distance and therefore between 150 and 170 ms to cross an image between the starting position and the target image. During this movement, the element is briefly unblurred on screen. **Figure 4** shows examples of this movement at the beginning of rounds 4–7. The density of the duration of interactions in **Figure 3** shows how often participants interact with elements for certain durations. The bimodal distribution suggests that there are at least two different types of behavior recorded. Shorter interactions, in **Figure 3** marked as the local maxima around 44 ms, are distinctly different from longer hover times peaking around 437 ms. A cluster model fitted to the log-transformed duration using two components (Scrucca et al., 2016) classifies 17,849 interactions as short and 63,452 as long, divided at 130 ms. The predicted movement time according to Fitts' law and the identified time dividing the bimodal distribution of hover times suggest that the shorter engagements with elements might be movements across the element, targeting another one. If participants follow the mouse movement and see the intermediately unblurred image on screen during the shorter engagement, the following unblurred target image acts as a backward mask. Previous research does not provide evidence for perceptual discrimination between visual stimuli shown for less than 100 ms (VanRullen and Thorpe, 2001; Zoefel and VanRullen, 2017). Furthermore, Salti et al. (2015) argue for a required exposure of more than 250 ms necessary to consciously perceive a stimulus. Assuming that specific information from a higher conceptual level is required to identify remote associations in the "Dira" task, these activations would require additional time, as Quiroga et al. (2008) have shown in single neuron recordings. For the "Dira" experiment we are interested in interactions for which participants can distinguish between different images. Concluding the different cited streams of research we assume that shorter interactions from the bimodal distribution shown in **Figure 3** have no or little influence on the process "Dira" intends to capture. In accordance with Fitts' law, we assume that the shorter observed behavior represents mouse movements across elements moving for a different target without cognitive processing of the image. Consequently, element interactions below the identified 130 ms are excluded from further analysis.

4. RESULTS

We first report on the type of raw behavioral data collected during the "quiz" and derived measures such as the chronology of information acquisition. Secondly we present the self-reported measures collected during the "rating" screen. We then show that the number of interactions with elements relates to the reported strength of the Eureka experience. Finally, we report results of the length of different interactions in comparison to the reported strength of reported Eureka experience. For the statistical tests we adopted a critical α level of 0.01 as originally put forward by Melton (1962) and Trafimow et al. (2018). For each test where the estimated amount of false discoveries surpasses this threshold, we transparently report this value as suggested by Lakens et al. (2018). We adopt this practice for our study and the chosen traditional threshold, in particular since the discussion on statistical testing is far from over (Benjamin et al., 2017; Trafimow et al., 2018).

4.1. Available Process-Tracing Measures

Participants' interaction with elements on the "quiz" screen is a metric for tracing their problem solving process. The time to produce solutions has previously been used in convergent thinking tasks (Salvi et al., 2016) and divergent thinking tasks (Forthmann et al., 2017), a measure that is similar to the "quiz time" in this paper. "Dira" employs a novel method by collecting behavioral data, namely the interaction times with the stimuli, throughout the creative process. This is a novel approach by shifting the focus from measuring the duration to produce a "creative product" to providing chronological measures of the process itself. While the current paper focuses on the moment solutions emerge, the experimental paradigm could be used to trace other aspects of the creative process such as preparing for the task or the verification of solutions. Since the extracted behavioral measures are vital for understanding the subsequent writing, we elaborate on the raw data and their derived measures in this section.

To illustrate the kind of data collected in "Dira," we will now discuss in detail **Figure 4**. The duration of interaction with each element is the difference between offset and onset time which is the raw data recorded during the task. **Figure 4** shows the example of one participant's interaction within the first 10 seconds of each of the 40 rounds. Each of the colored bars represents a timespan during which the mouse pointer hovers on top of an element. The length represents the duration, and the color signifies with which element the participants interact. For example, in the first round on the bottom of **Figure 4**, this particular participant spent a long time on "image b" (for color and naming scheme see **Figure 1**). The second round instead starts with three short interactions with "image d," "image e," and "image b" followed by a short time without any element interaction before hovering on top of the "text" for almost two seconds. Some rounds, like the third one, are finished within the ten second period shown in **Figure 4**, others like the first two continued for a more extended period.

Figure 4 also shows additional data that is available in "Dira." We refer to the moment participants select their solution as the "quiz time" since it ends the current "quiz." This measure is similar to existing measures in other tasks, such as the total time to solve convergent thinking tasks as reported by Salvi et al. (2016) or to produce utterances for divergent thinking tasks (Forthmann et al., 2017). The example participant selects

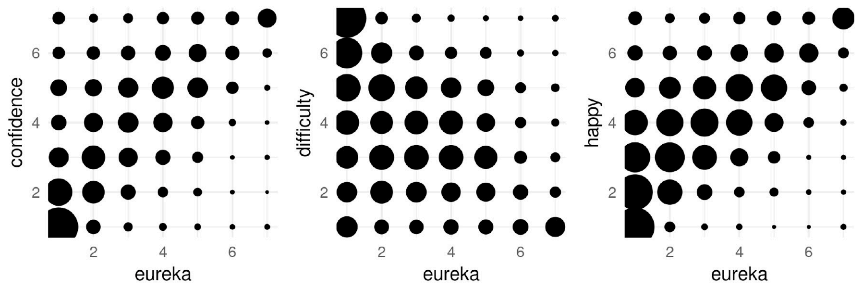

FIGURE 5 | Confidence, perceived task difficulty, and happiness related to the reported strength of the Eureka experience. The size of the circle represents the number of rounds in which the combination was reported, larger circles representing more answers.

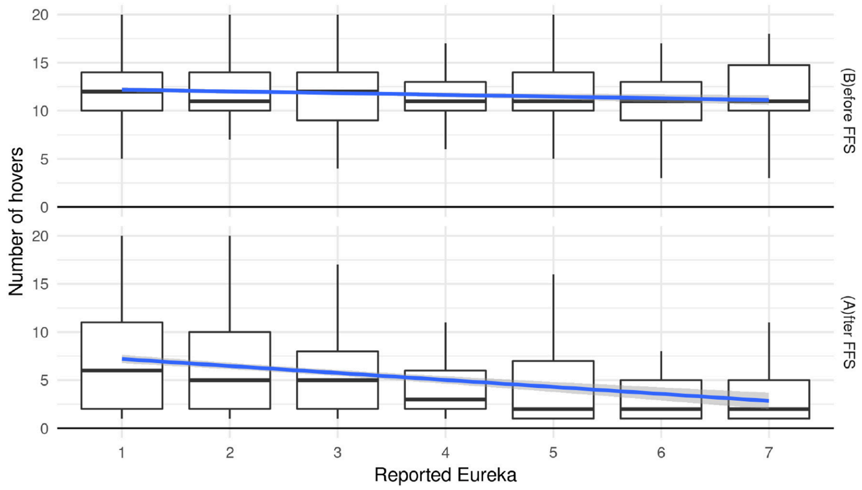

FIGURE 6 | Number of hovers before **(Top row)** and after **(Bottom row)** "First Full Scan" over the reported strength of Eureka experience.

the solution for round 3 at around 8,500 ms and round 4 at around 8,000 ms. The selected solution, for example, "image c" for round 3, is also indicated as a horizontal black line for the rounds in **Figure 4**. The vertical black line marks the end of what we call the "First Full Scan," the end of the interaction with the seventh unique element. Participants have interacted with each element at least once at the end of the "First Full Scan." The number next to the vertical axis in **Figure 4** represents the strength of the Eureka moment participants indicate during the "rating" screen. The example participant had no Eureka experience in round 2 and 3, but a strong one in round 19 and 26. Finally, the green box next to the vertical axis indicates rounds that are part of the analysis and not filtered out for one of the reasons explicated previously.

We administered "Dira" in three different conditions with a between-subject design as introduced in section 3.1. Based on the previously provided argument we hypothesized a longer interaction time for conditions 2 and 3. To test this, we built two linear mixed-effects models. Firstly we used the length of the First Full Scan as a dependent variable with the participant and round of the experiment as a random effect. We found no evidence for a difference between the three conditions ($\chi^2(2) = 2.4$, $p = 0.3$). In a second model, we used the quiz time as the dependent variable as it is most similar to the task time used in other tasks (Salvi et al., 2016; Forthmann et al., 2017). With participant and round of the experiment as random effects, we found no evidence that would support an effect of the experimental condition on time to report a solution ($\chi^2(2) = 0.87$, $p = 0.65$). Without support for the effect of the experimental conditions, there is no argument to distinguish between the three conditions regarding behavioral data.

4.2. Available Self-Reported Measures

Participants in the "Dira" task are required to provide self-reported measures in addition to the implicit behavioral data collected during the "quiz." During the "reporting" screen they are asked to account for the strength of their just encountered Eureka experience, their confidence in the given solution, the perceived difficulty of the task, and their current happiness on seven-point Likert items respectively. Besides, participants in condition 2 and 3 are also asked to rate how well they understand the connection between the text and a potential solution. In condition 3 they are furthermore asked to write down how their solution is associated with the text. These measures are collected during each of the 40 rounds. In section 3.1 we hypothesized an increase in the reported Eureka experience for condition 3. Nevertheless, this is not supported by the collected data ($\chi^2(2) = 4.81$, $p = 0.09$). Consequently, we cannot maintain a separate analysis for the self-reports in the three conditions.

As illustrated in **Figure 5**, for rounds in which participants report a strong Eureka experience they are also confident regarding their solution. Rounds with weaker or no Eureka experience are reported across the whole spectrum of confidence, but with a tendency toward low confidence as well. Instead, rounds with strong Eureka experiences are rarely rated as low confidence. This asymmetry leads to an overall Spearman's rank correlation of $\rho = 0.62$, $p < 0.01$. In contrast, rounds with strong reported Eurekas rank low in difficulty and rarely as "hard to come up with a solution." Rounds with a low or no Eureka experience are perceived with varying difficulty. The overall correlation between the reported Eureka experience and stated task difficulty is $\rho = -0.41$, $p < 0.01$. Finally, for weak or no perceived Eureka, participants express a range of

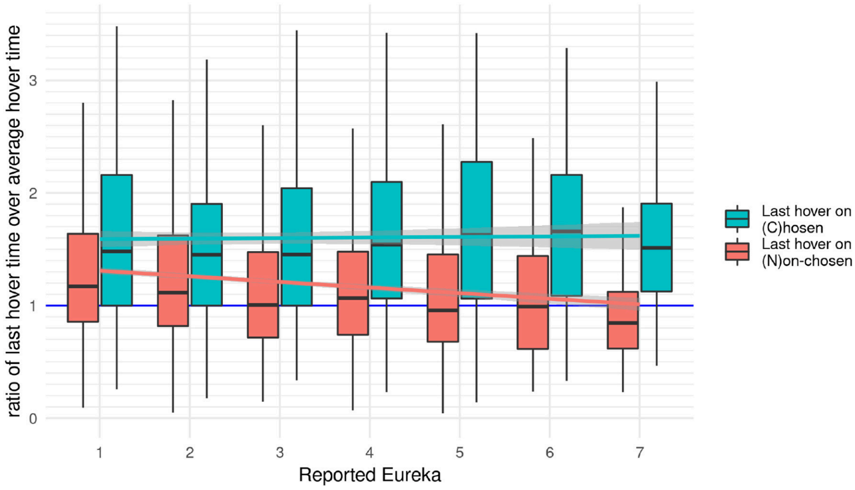

FIGURE 7 | The ratio between the last hover time within the First Full Scan and the average of all other hover times in the "First Full Scan," separated by rounds in which participants hover over the chosen image last vs. the ones they look at another picture. A value of one means that they are equal, lower than one means the last scan is shorter than the previous ones. In addition to the box-whisker plot (showing the median and distribution), the lines show a linear model fitted to the mean ratio and surrounded by the 95% confidence interval in light gray.

different happiness, but only high happiness for strong Eureka experiences. Reported Eureka and happiness are correlated by $\rho = 0.6$, $p < 0.01$. The reliability of the rating is either good for reported Eureka ($\alpha = 0.86$) and difficulty ($\alpha = 0.87$), or acceptable for happiness ($\alpha = 0.78$) and confidence ($\alpha = 0.77$) based on Cronbach's alpha. Conceptually these four measures are linked by the literature review of Topolinski and Reber (2010a), who discuss the relationship between ease, positive affect, and confidence to insight. This link is reflected by the data collected in "Dira" with good reliability suggested by Cronbach's $\alpha = 0.86$ across the four measures. Consequently, these findings confirm our second hypothesis that participants can report their experience on more than a binary scale.

4.3. Number of Interactions

In this section, we take a first look at the relationship between the self-reported intensity of the Eureka experience and the chronology extracted from the behavioral data. For example, when participants acquire information during the "quiz" and they find a solution, they might stop looking at more images. Therefore we hypothesize that the Eureka experience is stronger for rounds with fewer interactions. **Figure 6** shows how many elements a participant interacts with during each of the 40 rounds of the "Dira" experiment. The sub-figure on the top shows the number of interactions during the "First Full Scan" before participants have seen each element at least once. An average of ten to twelve interactions means that participants tend to go back and forth between elements even before they have seen all seven elements. More specifically, if participants look at elements in a certain order, looking back at one element and then continuing with the round can result in two additional interactions. To give an example: one participant has looked at "image a" and "image b" and then goes back to "image a" before continuing with "image b," "image c," and "image d." In this case, the participant had interacted twice with "image a" and "image b" during the "First Full Scan." This particular round would have accounted for at least nine interactions before the end of the "First Full Scan." To arrive at the numbers shown in **Figure 6**, this seems to happen twice in a typical "First Full Scan."

To test the above hypothesis, we built an ordinal mixed-effects model (Christensen, 2015) with reported Eureka as a dependent variable. The number of interactions, the classification into before and after "First Full Scan," and the experimental conditions were used as predictors. The rounds of the experiment as well as participants were considered as random effects. Results from this model indicate that there is a significant negative effect (estimate $= -0.06$, $z = -6.27, p < 0.01$) of numbers of hovers on the reported Eureka before the end of the "First Full Scan." The model also shows a significant negative effect (estimate $= -0.35$, $z = -3.68, p < 0.01$) for the number of interactions after the end of the "First Full Scan." This confirms our hypothesis for the interactions during and after the "First Full Scan." On the other hand, there is no evidence that condition 2 or 3 have an effect compared to participants in condition 1 (estimates $= [-0.12, -0.28]$, $z = [-0.35, -0.88]$, $p = [0.73, 0.38]$).

During the "First Full Scan," the above model shows a significant effect of the number of interactions with elements on the strength of the Eureka experience. Across all conditions, this

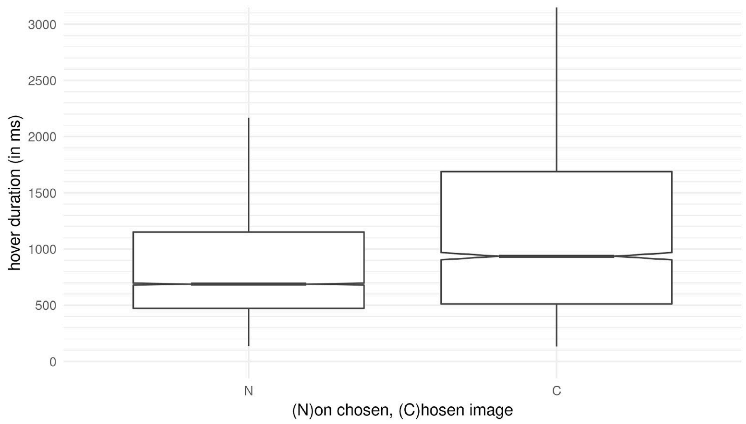

FIGURE 8 | The hover duration on the images within the First Full Scan. The time on the (C)hosen picture is longer the time on the five other images that are (N)ot chosen.

difference is between 12.61 interactions for no or low Eureka experiences and 11.38 interactions for strong reported Eurekas. After the "First Full Scan" participants do not interact with all the images and text, again. The significant effect of the number of interactions on the reported strength of Eureka is higher this time and more pronounced in **Figure 6**: the difference is between 9.65 interactions for no experience of a Eureka and 4.24 interactions for a strong one. There is no evidence for an effect of the experimental condition on these results. Considering that the behavior of participants with different Eureka experiences seems to change before the end of the "First Full Scan," it is of interest to examine the behavior during the "First Full Scan" in more detail. Hereafter we will examine whether the duration of hovering over elements provides additional information.

4.4. Last Hover During First Full Scan

Here we report the results for the hover duration on the seventh unique element. It is the last image during the "First Full Scan" and the first time participants interact with this specific element. Following up on the previous finding of an interesting difference between interactions during and after the "First Full Scan," we want to narrow down the time of emerging solutions by exploring this specific hover time. More specifically we show the ratio of the duration on the last image compared to the mean of previous interactions. The chronometrical measure of hover time is illustrated in **Figure 7**. To correct for individual differences in processing speed, we plot the ratio of the hover time on the last image and the average hover times on all other images during the "First Full Scan." **Figure 7** plots separately the ratio of rounds in which this element is the one (C)hosen later in the experiment and rounds which end on a (N)on-chosen one.

Figure 7 shows two effects: Firstly, for the "First Full Scans" ending on a chosen image, the median of the hover time is roughly 50% higher on that element than for non-chosen ones (1,323 vs. 855.9 ms). Secondly, less time seems to be spent on the last non-chosen image than on the previous ones for stronger Eureka experiences, whereas more time is spent on the last image for low Eureka values. To quantify these effects we built an ordinal mixed-effect regression model with the strength of the reported Eureka experience as a dependent variable and the ratio, the type of element for the last hover, and the experimental condition as predictors. The round of the experiment and the participant were used as random effects. This model shows a significant effect of the ratio on the strength of the reported Eureka (estimate $= -0.24$, $z = -6.1$, $p < 0.01$). It further shows a significant effect for rounds in which the last element is the chosen one on the strength of the reported Eureka (estimate $= 0.2$, $z = 2.71$, $p < 0.01$). There is no evidence for the ratio in condition 2 or 3 affecting the reported Eureka intensity (estimate $= [-0.09, -0.55]$, $z = [-0.32, -0.32]$, $p = [0.75, 0.05]$).

The negative slope of the ratio over the strength of Eureka, in **Figure 7** particularly evident for the last hover on the non-chosen image, suggests that a solution has emerged before the end of the "First Full Scan." The change of the ratio is either the result of a decrease of the numerator, an increase of the denominator, or a combination of both. The numerator decreases if participants spent less time on the last image when having a stronger Eureka experience. The denominator represents the average time spent on all previous images. It increases if participants spend more time on at least one of the previous images. If participants had Eureka experiences while looking at the image they are going to choose later, and this would be associated with them looking longer at that image, this would increase the denominator in the rounds which end on the non-chosen images. The observed increase would also explain the difference between rounds that

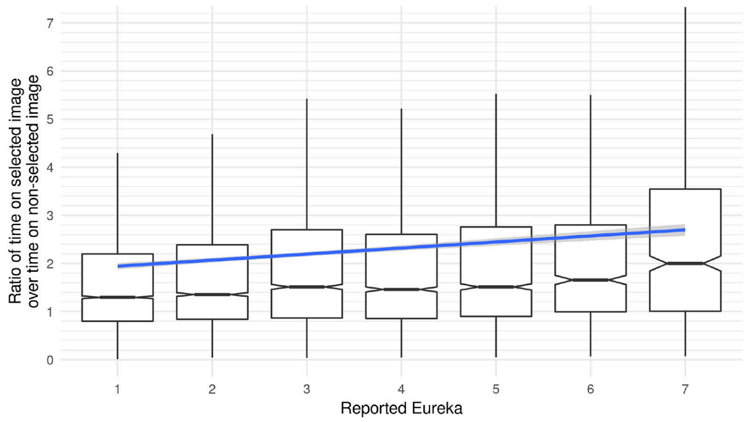

FIGURE 9 | The ratio of time spent on the chosen image over non-chosen images as a box-whisker plot with a linear model fit to the mean. The median for the ratio depicted in the box-whisker plot shows that participants spend nearly 1.3 times as much time on the chosen image compared to the others for a low Eureka, but about twice the time for a strong Eureka. The difference between mean (linear model) and median (box-whisker) results from outliers in the data.

end on chosen and non-chosen images. If participants spent less time on subsequent images, for example after a Eureka experience, this would decrease the numerator for the rounds ending on non-chosen images, but not for the ones ending on the chosen images. This interpretation of the observations suggests that the measured ratio is a compound of chronological effects and hover duration. Therefore we focus now on the duration spent on the chosen image and its relation to the strength of Eureka.

4.5. Chosen Images and Length of Interactions

The observation of the ratio of interaction times during the "First Full Scan" suggests that the interaction times between chosen and non-chosen images differ. Instead of a compound measure, we purely show the duration of hover times during the "First Full Scan" on (C)hosen and (N)on-chosen images in **Figure 8**. A Mann-Whitney test indicates that the duration of viewing chosen images (duration = 935.9 ms) is significantly longer than for non-chosen pictures (duration = 687.8 ms), $U = 20{,}873{,}370$, $p < 0.01$). Furthermore, there is a significant difference between the three conditions regarding the hover duration on non-chosen images ($H = 42.07$), $p < 0.01$ $Md_{\text{Condition 1}} = 663.2$, $Md_{\text{Condition 2}} = 679.7$, $Md_{\text{Condition 3}} = 727.9$), according to a Kruskal-Wallis test. Furthermore, there is a difference between conditions for the chosen images ($H = 9.18$, $p = 0.01$, $Md_{\text{Condition 1}} = 879.8$, $Md_{\text{Condition 2}} = 915.9$, $Md_{\text{Condition 3}} = 1{,}048$). Participants spend a significantly longer time on the chosen image in the third condition than in the other two conditions, and more time in the second condition compared to the first one.

We now look at the link between hover duration and reported Eureka experience in more detail. We built an ordinal regression model with the reported strength of the Eureka experience as the dependent variable. With the hovering time on the chosen images as a predictor, we failed to find evidence for a link between the strength of the Eureka and interaction time (estimate = 0.01, $z = 0.21$, $p = 0.83$). This is not unexpected since the raw data include slower and faster participants. Instead, if an ordinal mixed-effects model considers the participant as a random effect, the evidence supporting the link between hover duration and Eureka experience surpasses the threshold (estimate = 0.14, $z = 3.16, p < 0.01$). From this example we conclude that the recorded raw hover durations with text and images have little validity in connection with the self-reported measures collected during the "rating" screen. To address this, we remove the influence of participants and the task by considering the ratio between the time spent on chosen and non-chosen images calculated separately for each round. This suggested ratio between interaction times for a single round and with a single participant does not include chronological components related to the order of interactions; it is between measured times only.

Figure 9 shows the ratio between the hover duration on the chosen image and the average time spent on the other images. This ratio is higher for rounds in which participants report a stronger Eureka experience. An ordinal mixed-effects model fitted to the data supports this observation. The model uses the strength of the reported Eureka experience as a dependent variable and the ratio between the time spent on the selected image compared to the average duration on all other images as well as the experimental condition as a predictor. The round of the "Dira" task and the participant are used as random variables.

This model confirms that an increase in the ratio corresponds to a stronger Eureka experience (estimate $= 0.02$, $z = 5.65$, $p < 0.01$). With a ratio of 1.3 for no Eureka and 2 for a strong Eureka, participants seem to spend approximately 50% more time on the chosen image in rounds when they report a strong Eureka experience. However, the model does not provide evidence for an influence of condition 2 or 3 on the reported Eureka (estimates $= [-0.1, -0.58]$, $z = [-0.33, -2]$, $p = [0.74, 0.05]$).

Here we have presented two main findings. Firstly, the observations of the length of interaction with elements show that participants spend more time on the images they will select later in the task. Secondly, for rounds with a strong reported Eureka experience, the time spent on the chosen image is significantly longer than in rounds with a weaker or no Eureka experience.

5. DISCUSSION

The moment when a solution to a problem emerges is an extraordinary experience. It causes people to cry out "Eureka" (Pollio, 1914), "Aha" (Bühler, 1908), or "Uh-oh" (Hill and Kemp, 2016) and often their mood increases. In this paper, we suggest "Dira" as a novel experimental paradigm to observe these moments as part of the creative process. Many previous studies rely on the judgement of creative products, persons, or press (Rhodes, 1961)—or use proxy phenomena to assess the process contributing to creativity, innovation, and problem solving. In this study, we tested 124 people who participated in a controlled lab experiment designed to study the emergence of solutions. "Dira" records behavioral data during each task to observe the creative process directly. Specifically, we determine the chronology and chronometric measures of participants' interaction with potential solutions. After each task, we ask the participants to self-report their experience on four different items. Here we discuss the implications of combined behavioral and metacognitive measures in the "Dira" task.

5.1. Eureka Experiences in "Dira"

Results from the behavioral data within the "First Full Scan" of "Dira" show that participants spend longer times on images they are going to select as their solution. Moreover, the length of the interaction on these chosen images is linked to the strength of the reported Eureka experience, with longer hover durations associated with stronger Eureka experiences. As shown in section 4.4, the median interaction time on the chosen image is about 50% longer than on the non-chosen ones. Another result related to the strength of Eureka is reported in section 4.5. For rounds that evoke a strong Eureka experience, participants spend about 50% more time hovering on the chosen image as compared to rounds with no or low reported Eurekas. The current analysis does not allow drawing any conclusions regarding causality. Future studies could test if more extended engagement yields stronger Eureka experiences or if stronger Eureka experiences lead to longer hover durations.

After participants have interacted with the chosen image, they are less likely to continue looking for more elements according to the results in section 4.3. Supposedly participants continuously scan the elements on the screen for a solution. If they find an association, the number of elements they interact with afterwards is related to the strength of the Eureka experience reported later. The significant effect can be observed as early as during the "First Full Scan" and the initial interaction with the images. These results suggest that something distinctive might already be happening during the initial engagement with the images.

With support from the ordinal mixed-effects model considering behavioral and self-reported measures, we confirm our first hypothesis that behavior happening during the "quiz" results in the reported intensity of Eureka. It would seem natural that the Eureka experience also happens during this time. However, it is not impossible that the Eureka experience is the result of a post-event evaluation. In any case, due to the short quiz time, these experiences would qualify as immediate insights according to Cranford and Moss (2012). In their study of convergent thinking, they found a difference between solutions found through a "classical insight" sequence and "immediate insights." The immediate insights only consisted of an "Aha!" or Eureka experience and were considerably faster. This quick insight is also in line with the idea of intrapersonal creativity or mini-c introduced by Beghetto and Kaufman (2007). It would be interesting to design a modified version of "Dira" to elicit non-immediate insights as well, for example by tapping into the thought suppression as used in the delayed incubation paradigm (Gilhooly et al., 2014) or more generally in "little-c" type of tasks. We leave this speculation for future studies.

5.2. Subjective Experience

In more detail, the strong Eureka experience in rounds with high confidence is consistent with previous findings, for example by Hedne et al. (2016). In their study on magic tricks, problems solved via insight were rated with higher confidence than problems solved without insight. Previously Danek et al. (2014) had assessed a higher confidence rating for insight solutions as well, but they had used confidence in the definition of insight given to the participants, so this could have been a potential confound in their results. Hedne et al. (2016) also explicitly link confidence with the correctness of the solution, and Steele et al. (2018) highlight that confidence predicts a creative outcome. Further support comes from Topolinski and Reber (2010b) and Salvi et al. (2016) who identified a higher probability to be correct for insight solutions in convergent thinking tasks.

Happiness and, more generally, a positive mood is strongly linked to insights and Eureka experiences in the existing literature. In the "Dira" task participants experiencing a strong Eureka seldom report low happiness, but instead are consistently happier than with weaker or no Eureka experiences. The meta-review of Baas et al. (2008) provides a comprehensive overview of the relationship between mood and insight. More recently Shen et al. (2015) explore 98 different emotional states and their relationship to "Aha!" experiences. Results from their studies 2 and 3 suggest a link between insight and happiness—along with a list of other positive emotional states.

The mapping of states in two dimensions affords that other emotions could mask happiness for weaker Eureka experiences. While Abdel-Khalek (2006) finds single-item measurements of happiness sufficient to assess related positive affects and emotions, the fine-grained exploration of the emotional space associated with emerging solutions could be a topic for future research.

Our results for the relationship between difficulty and Eureka show that "Dira" tasks with a strong Eureka experience are rarely perceived as difficult. This finding seems counter-intuitive from the perspective of the classical "insight sequence" (Ohlsson, 1992) in which a complicated impasse has to be navigated. However, perceived difficulty can change in hindsight. Even if the task appears to be problematic while working on it, Topolinski and Reber (2010a) have shown that having an insight can change this. In a review of the literature, they identify a change of processing fluency as a result of having an insight. After having found the solution, they conclude, the problem appears to be easier than it was during the attempt to solve it. Alternatively, yet another interpretation is that the participants experience insights in tasks that are not difficult for them.

5.3. Differences Between Conditions and Personalities

In section 3.1 we provide a theoretical argument for administering "Dira" in the three different conditions. In particular, we hypothesized providing a potential solution would result in an increased interaction time. The collected data do not support this hypothesis as the results in section 4.1 show. We had further assumed that the additional task of elaborating on the chosen solution would increase the interaction time and change the self-report. As section 4.2 demonstrates, the data do not provide evidence for this effect. This could either mean that the theoretical argument is not sound and additional variables would influence the measurements to an extent that masks the hypothesized effect. Furthermore, the introduced interventions might tap into different effects than expected. Assuming that the theoretical argument is valid, the effect size could be too small or "Dira" as an instrument not sensitive enough to measure the effect within the sample. In summary, there is no evidence that supports a difference between the behavioral or self-reported measures among the three conditions.

In a trial-by-trial comparison, we reveal a link between fewer interactions and stronger Eureka experiences. In section 4.3 we compare the differences in the number of interactions observed between Eureka intensities, separately during and after the "First Full Scan." We observe a significantly larger variance between no and strong Eureka experiences after the "First Full Scan." This difference implies that the experience is influenced by element interactions and not by the participants' distinctive approach to the task. On the other hand, individual variability might moderate the experience and performance in the "Dira" experiment. Future research could expand the method we suggest to address the relationship with personality traits. Specifically, "Dira" could be used to test if traits known to correlate with creative production (Batey et al., 2010) predict eureka experiences.

5.4. Experimental Control

The participants' freedom to choose the order and duration of stimulus interaction is supposed to increase task engagement, but it does not come without costs. The flexibility to look at elements in any order allows participants in the "Dira" experiment to not look at elements necessary to solve the problem. For example, some participants choose not to look at the text before selecting one of the images. Furthermore, participants who start with the text and try to find a matching image afterwards might use a different approach to solve the problem than others who engage with images first and interact with the text later during the task. In the first case, they only need to store the text itself or a derived concept in working memory to match it against each of the images they look at. In the second case instead, they need to remember up to six images and related concepts to match each of them with the text. In the current study, we filtered for rounds in which participants started with the text and removed all others. Future studies could eliminate the second case by specifying the chronology, for example by showing the text first.

As discussed earlier, the bimodal distribution of hover durations suggests that participants unblur elements for at least two different reasons. As discussed in section 3.5, participants might either intend to move the mouse pointer across by targeting elements on the other side or consciously engage with the text and images. In the current study, we assumed interactions shorter than 130 ms to represent mouse movement across elements. While these interactions were removed *post-hoc* from the current study, avoiding short unblurring could be implemented in the experimental design. The elements could only be shown clearly if the hover time exceeds the movement time predicted by Fitts' law (Soukoreff and MacKenzie, 2004).

6. CONCLUSION

In the "Dira" task, we estimate the moment of the emerging solution based on the participants' behavior and self-reports without relying on additional indicators. Like in many design and engineering problems, more than one solution is correct for this task. For "Dira" we demonstrate how behavioral data and meta-cognitive monitoring are integrated by this instrument to identify sub-processes of the creative process.

The results suggest that participants can distinguish between Eureka experiences of different strengths. Thus, our results suggest that Eureka experiences are not limited to having or not having an insight, but that the perception of this experience can have different intensity levels. Future studies should keep this in mind when assessing Eureka experiences.

Looking at the whole process of finding a solution to an ill-defined problem, people experience something early in the problem solving process that they relate to the Eureka experience. While the exact timing remains unclear, observations in "Dira" help narrowing down insight and other sub-processes. For example, before seeing all the elements in the "Dira" task, participants in our study exhibit distinctive behavior related to the strength of their reported Eureka experience. Our results suggest that immediate insights exist and can be reported by people who experience them.

The creative process is often studied indirectly through the creative product, person, or press. We propose "Dira" as an experimental platform to record behavior as Eureka experiences are happening. This instrument and future studies applying the same underlying principle can bring us another step closer to understanding the creative process.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of Plymouth University Research Ethics Policy, University Research Ethics and Integrity Committee. The protocol was approved by the Faculty Psychology Research Ethics Committee. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

AUTHOR CONTRIBUTIONS

FL: design of experiment, implementation of the experiment, data collection, data analysis and interpretation, write up; JG: design of experiment; GB: design of experiment, data analysis and interpretation, paper structure and edit.

ACKNOWLEDGMENTS

The authors want to thank Dr. Katharine Willis for her insight that creative tasks, for example in Architecture, have more than one solution. This work was supported by CogNovo, a project funded by the University of Plymouth and the EU Marie Skłodowska-Curie programme (FP7-PEOPLE-2013-ITN-604764).

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AVANT, Vol. VIII, Special Issue
ISBN: 978-83-944622-04-6 avant.edu.pl/en
DOI: 10.26913/80s02017.0111.0005

Navigating Cognitive Innovation

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Received 12 May 2017; accepted 26 September 2017; published 21 November 2017.

Abstract

This paper revisits the concept of Cognitive Innovation with the aim of helping newcomers appreciate its (intended) demarcating purpose and relevance to the wider literature on cognition and creativity in the humanities, arts, and sciences. Particular emphasis is paid to discussion of the pitfalls of sense-making and the concept's affordance. The main argument presented is that proponents of the concept face the dilemma of seeking to demonstrate its transdisciplinary nature and applicability vis-a-vis retaining its semantic distinctness. Proceeding from a classification of Cognitive Innovation as a dispositional construct, we discuss how it feeds into existing research approaches and opens up new sensibilities in related areas. The perspectives of temporality, interdisciplinary balancing, technology, and metatheories are proposed as promising areas for future elaboration of the function of Cognitive Innovation.

Keywords: concept analysis; creativity; interdisciplinarity; metatheory; temporality.

Introduction

In her seminal paper on concept analysis, Rodgers argues that intellectual progression is greatly impaired when definitions and attributes of fundamental concepts are not made clear: "[Q]uestions regarding vague or ambiguous concepts are met with confused responses that are dependent upon individual and often ad hoc interpretations" (Rodgers, 1989, p. 330). Conceptual unclarity characterizes several research areas that have become tantalizing in cognitive science within the last decades, including creativity, consciousness, cognition and play. Research that proposes measures of creativity or attempts to determine neural correlates of creativity is often criticized not on the basis of its methodological rigor, but on the basis of its claim to represent the concept of creativity. At the same time this might also be the root of disagreement between different lines of research.

Lack of clarity regarding the concept of creativity has been a recurrent theme within CogNovo's[1] network of principal investigators, PhD students, affiliates, and partners, where presentations on creativity have often extended into dead-end discussions about fundamental ontological and epistemological questions. In order to overcome these discursive impasses, Denham and colleagues proposed the notion of Cognitive Innovation to help position (or perhaps displace) creativity. In this paper, we draw attention to the notion of Cognitive Innovation as we understand Denham (2014), Gummerum and Denham (2014) and Denham and Punt (2017), collectively referred to as "Denham and colleagues."

To help tighten the grip of the concept's unique affordance, we examine a series of issues regarding interpretation and comprehension of the depictions by which the concept comes into expression. Our aim is twofold: first, to help newcomers to the concept appreciate its (intended) demarcating purpose; second, to suggest new approaches to interdisciplinary research on cognition.

Cognitive Innovation as a Neologism

The notion of Cognitive Innovation was coined long before the recent rendering by Denham and colleagues, when Acker and McReynolds (1965) introduced the Obscure Figures Test as a measurement of Cognitive Innovation. Their paper references a talk at the annual convention of the American Psychology Association as the source of the term, but the available proceedings do not mention it at all (McReynolds, 1964). Presumably the term was discussed during the talk and summarized in Acker and McReynolds (1965):

> It is conceived that in the course of his commerce with his[2] environment, an individual builds up an over-all cognitive structure which for him represents the nature of reality and in terms of which input data should be processed. This over-all cognitive structure can be assumed to undergo certain changes over time. The processes whereby these changes are brought about are what is meant by "cognitive innovation," i.e., innovation or the introduction of newness into the cognitive structure. (p. 851)

[1] CogNovo started as a doctoral training program at Plymouth University, jointly funded by the EU through the Marie Curie Actions and Plymouth University. For an overview of the CogNovo program (https://CogNovo.eu) and its twenty-four research projects, see Maranan, Loesche, and Denham (2015).

[2] For clarification: even though only male performance is discussed, females and males participated in the study. Presumably the assumption and results apply to both genders, even though the wording suggests otherwise.

The cognitive structure mentioned here resembles to some extent imagery or mental representation and individual knowledge. The manipulation of internal structures towards something novel is what Acker and McReynolds (1965) address with their use of the term Cognitive Innovation. Denham and colleagues also mention such manipulation as a key property in their articulation of the concept. Interestingly this exhibits some overlap between the two uses of the term, without explicit reference.

In perhaps the most succinct linguistic definition available from their contributions, Denham articulates the concept of Cognitive Innovation as "a recursive process in which an individual probes its boundaries to seek out new knowledge, selects promising avenues for more extensive exploitation, and synthesizes what it learns within its growing body of knowledge" (Denham & Punt, 2017, supplement, p. 4). Denham refers to Cognitive Innovation as a generic and recursive function manipulating not just the imagery (and other explicit knowledge), but also the individual's set of internal mental processes and the Cognitive Innovation function itself. The sum of sensory inputs is the third distinct parameter feeding into the Cognitive Innovation function. In its functional form, Cognitive Innovation is presented as

$$F_{t+dt}, x_{t+dt} \Leftarrow F_t(F_t, x_t, s_t)$$

where

> F represents the mental processing of an individual, and the set of things it knows about, . . . F_t represents all internal (mental) processes, is the set of ideas, facts, words, and so on that are known by the individual and can be exchanged with others, s_t are things in the world perceptually accessible to the individual and t is an index of time. (Denham & Punt, 2017, supplement, p. 5)

Cognitive Innovation as a Dispositional Concept

Whereas Denham and colleagues seem to have a strong idea about the essence of Cognitive Innovation, we draw attention to the question of how to make sense across the vast range of disciplines that are engaged with cognition and innovation. Lack of familiarity with the concept poses at least two pitfalls in terms of sense-making.

First, the reallocation of meaning to a compound term which makes use of omnipresent words with rich historical semiotic loads requires the term to be freed from unintended meanings. Familiarity with its constituting terms of cognition and innovation may misleadingly activate interpretations that combine unintended attributes of both. Cognitive science forms its own research domain, including a set of disciplines at the intersection between neuroscience, anthropology, artificial intelligence, linguistics, philosophy, and psychology (see Thagard, 2005, p. X [sic]). Innovation appears to be used within social sciences and economic and engineering literature, with an emphasis on multi- and interdisciplinary work (see Crossan & Apaydin, 2009; Fagerberg, Fosaas, & Sapprasert, 2012). As a result, innovation has a number of definitions across and within different disciplines, often related to the "implementation of creative ideas" (Amabile, 1988, p. 126) and echoing two dimensions also used for the definition of creativity on individual levels of novelty and usefulness (see Runco & Jaeger, 2012; Stein, 1953), but typically measured on an organizational level (Sawyer & Bunderson, 2013, p. 14). In short, we note that each of the constituting elements of Cognitive Innovation are very rich and semantically overloaded. As opposed to the blank slate approach of inventing an artificial word to describe the concept, cognition and innovation—to stay within the metaphor—have chalk scribbles dense enough to provide some colored but almost indistinguishable background. At the same time, this approach situates Cognitive Innovation in approximation to metatheories, involving humans and human behavior.

A second (general) pitfall of sense-making is that one thing is understood in terms of something else, be it an existing conceptual framework, terminology, or historical or cultural situatedness. Gadamer's (1960) notion of fusion of horizons (*Horizontverschmelzung*) eloquently captures the inevitable compromise that takes place during any text comprehension: two "horizons," i.e., scopes of insight restrained by "historically effected consciousness," are fused during the interpretative act—the horizon of the text and the one of the reader. Thus, the same description of Cognitive Innovation will most likely be understood quite differently by an expert on, say, Cognitive Flexibility Theory (e.g., Spiro, Coulson, Feitovich, & Anderson, 1988) than by an expert on epistemology (e.g., Archer, 1988). Both topics share similarities with Denham's description of Cognitive Innovation, but respectively emphasize the different aspects of learning and knowledge production. While aspects and insights from such related domains are commensurable with the description of Cognitive Innovation, it is impossible to determine in an absolute sense whether such aspects are intrinsic features of Cognitive Innovation. Denham may say they are, or are not, and someone else may say the opposite. Hereby a challenge regarding the conceptual clarity of Cognitive Innovation emerges: Denham's definition of the concept—a recursive process of exploration, exploitation, and synthesis—is expressed at a very high level of abstraction that is easily translatable or applicable to numerous domains and contexts. While this genericity may be embraced and leveraged, as exemplified by all the writings of Denham and colleagues, the question of the concept's boundary marking is left unresolved (except for the distinction between creativity and Cognitive Innovation).[3] Whether or not this semantic fluidity is a problem depends on the ontological underpinnings of the concept.

[3] Denham and Punt, however, seem to be aware of this contingent imposing of meaning onto the concept in acknowledging that what they are tackling "is, and also is not, necessarily the same thing" (Denham & Punt, 2017, p. 185).

Historically, concepts have been thought of as belonging to one of two categories (Rodgers, 1989): "Entity views" treat a concept as a clearly demarcated and stable "thing" with a rigid set of necessary and sufficient conditions. The essence and truth value of a concept can therefore be approached positively through a reductionist approach and should not be examined relative to some context. "Dispositional views," on the other hand, treat concepts as habits or behavioral potentials. In contrast to a fixed and reductionist approach, they acknowledge dynamic formation of concepts through individuals' interpretation and utilization as a sine qua non condition. We argue that the concept of Cognitive Innovation is a dispositional construct. This is perhaps most clearly expressed in the paper by Denham and Punt (2017), which articulates the concept on the basis of two distinct mindsets influenced by the domains of computational neuroscience and media archeology, respectively. Whereas this dual perspective arguably supports their intention to promote Cognitive Innovation as a focus for collaboration between the sciences, arts, and humanities, the format of the paper—two self-standing essays "in which the contributing specialisms retain their academic and methodological distinction and voice" (Denham & Punt, 2017, p. 184)—does not promote fusion of disciplinary horizons by example. Bearing this point in mind, the "bridge" from which Denham and Punt (2017) look at Cognitive Innovation (as indicated by the paper's title) is probably better understood as a nautical metaphor (i.e., the platform from which a ship is commanded) than as a construction that connects existing platforms across a gap. A pertinent question posed by this interpretation is: Where is the ship heading?

Charting New Territories in Cognitive Innovation

If we proceed from the assumption that Cognitive Innovation is a dispositional construct, we can begin to envisage how the concept feeds into existing research approaches and opens up new sensibilities. The following three strands of thought follow from our contemplation of the notational form of the functional definition of Cognitive Innovation.

Emphasizing the Temporality of Cognitive Innovation and Creativity

In cognitive sciences, creativity is assumed to be a stable trait that can be measured without changing it. Both the functional description of creativity by Denham and colleagues and their characterization of Cognitive Innovation instead emphasize their malleability to influences over time. Even in their notation, time might be overlooked as a small subscript to the parameters and results, but it is a subscript to every single parameter. Indeed time, it could be argued, should be more explicitly addressed in the study of creativity as it emerges from Cognitive Innovation.

The effect of task-specific training has been shown for divergent and convergent thinking (Scott, Leritz, & Mumford, 2004), as well as insightful tasks (Weisberg, 2014). This alteration of internal knowledge, as represented by *xt* in the Cognitive Innovation function, changes with repeated exposure and therefore time. Based on this empirical and anecdotal underpinning it is no surprise that time plays an important role in many theoretical models of creativity, such as the temporal stages mentioned by Wallas (1926) to Csikszentmihalyi (1988), and basically any idea that taps into the second "P" (Process) from Rhodes' (1961) "four Ps of creativity" model, which uses time as an independent variable.

Following up on this theoretical stance, it remains unclear how much the recursion of perceived time (for example, through Earth's rotations around the Sun and itself) or technologically and culturally constructed time (rotations of minute hands on clocks, "the same" bus every 7 minutes) itself is intrinsically reflected in the functional description by Denham and colleagues. Future discussions might want to address the effect chrono-biological or chrono-technological processes have on the recursion of Cognitive Innovation.

A temporal perspective can also be used to illustrate the difference between Cognitive Innovation and creativity. Denham and colleagues characterize creativity as an exaptation of Cognitive Innovation and appear to suggest that creativity is a contemporary and socially grounded expression of what is ultimately Cognitive Innovation.[4] The distinction can be perceived with a thought experiment: What was creativity (or what did people think about it) 10 years ago? Probably it was similar to what we think now. What about 100 years ago, when the word "creativity" first emerged in Western languages? What about 6,500 years ago, when the wheel was invented? What about 525 million years ago, when the first vertebrates emerged? 525 million years ago, creativity was probably "non-existent," whereas cognitive innovation probably did exist.

[4] Part of what distinguishes creativity from Cognitive Innovation is that the notion and valuation of creativity (and what constitutes a creative product, process, or person) is contingent on its environment in all its social, cultural, technological, and political dimensions. For instance, it has been suggested that social risk-taking is associated with creativity (Tyagi, Hanoch, Hall, Runco, & Denham, 2017); that is to say, what or who is creative is not necessarily considered socially acceptable. A second distinction of Cognitive Innovation from creativity—potentially also a consequence of the involvement of multiple agents—is the application or at least applicability of the resulting products. The formula Cognitive Innovation = creativity + communication + application is oversimplifying the idea of Cognitive Innovation as an "endless cycle of exploration, exploitation, and explanation" (see Gummerum & Denham, 2014, p. 586), but emphasizes the distinction to creativity nevertheless.

Decomposability, Balancing Interdisciplinarity, and Technology

The functional definition of Cognitive Innovation states that it is recursively constituted of an individual's mental processes (F), their existing knowledge (x), and properties of the perceptually accessible world (s). Denham and Punt (2017) further suggest creativity is constituted not only by the terms of the Cognitive Innovation function, but additionally by the knowledge (y) and cultural and societal processes (G) of the community (Denham & Punt, 2017, supplement, p. 10). We propose that the decomposability of Cognitive Innovation and creativity in such particular terms affords strategies for evaluating and advancing interdisciplinary research programs such as CogNovo.

First, it suggests that a research group studying Cognitive Innovation and creativity would best be served by a disciplinary mix that included not only cognitive neuroscience and psychology to cover terms F and x, but also cultural anthropology and political sociology (which were absent in CogNovo), perhaps with an emphasis on ethnography as a methodology. This complement of disciplines more fully corresponds to the components of the functions.

Second, it calls for reflection on the role that computational sciences and media studies play in the research agenda of an interdisciplinary research group studying human creativity. Why should computation, media, and technology matter in this field? In the creativity function, where do things like hammers, telescopes and mobile phones fit in? Strictly speaking, they are simply part of the perceptible world, s, yet they seem to be more significant than that. We suggest that technology (in the sense of apparatuses, equipment, and tools) might be considered to constitute a special aspect not only of the material, perceptible world (s), but also of societies' ways of thinking and doing (G). Describing the function of contemporary technology, Punt (Denham & Punt, 2017, p. 185) points out that technology serves to supplement the human body, either by "alleviat[ing] the hardships of nature through muscular amplification" (particularly in the past), whereas contemporary technology (also) extends the "limitations of the sensory range" of the human organism. Indeed, technology can, as McLuhan (1964) argues, be an "extension of ourselves" in that it extends the cognitive system as much as it can extend the body (Brey, 2000). Technology can play an active role both in perceiving the world differently and also in transforming it. We thus argue that technology deserves to be set aside as a special term in the creativity function. Hence, the creativity function

$$F_{t+dt}, x_{t+dt}, G_{t+dt}, y_{t+dt}, s_{t+dt} \Leftarrow F_t(F_t, x_t, G_t, y_t, s_t)$$

might be more completely described as

$$F_{t+dt}, x_{t+dt}, G_{t+dt}, y_{t+dt}, s_{t+dt}, T_{t+dt} \Leftarrow F_t(F_t, x_t, G_t, y_t, s_t, T_t)$$

where T stands for technology—the apparatuses, devices, and mechanisms that extend the body and brain, and thus arguably extends (or at the very least mediates) human agency (Latour, 1994). That is to say, the recursive, functional form of Cognitive Innovation and creativity facilitates an extended description of cognition that is much in line with theories of The Extended Mind (e.g., Clark & Chalmers, 1998). This transcends the focus on intra-cranial processes, which historically have been the object of cognitive studies.

Cognitive Innovation and Metatheory

The existing articulations of Cognitive Innovation do not explicitly mention any particular philosophical anchorage, nor do they claim to pertain to any context, historical era or culture. In this regard, the concept shares fundamental features with metatheories. One example of a metatheoretical framework with particular strong affinities to Cognitive Innovation is Clare Graves' Emergent, Cyclical, Double-Helix Model of Adult BioPsychoSocial Systems Development (e.g., Graves, 1974). Graves' lifelong project was to study no less than the developmental path of human nature. In the 1950s he began to collect anthropological and psychological data without having any hypothesis, in an approach similar to what was later formalized as Grounded Theory by Glaser and Strauss (1967). The culmination of his work was the proposal of a pattern and direction in the path of human development in the form of a framework that integrates various theories of human development, e.g., Maslow's (1943) hierarchy of needs, and Dawkins' (1976) idea of memes. On the basis of data collected over a period of more than 30 years, Graves proposed seven developmental levels of being or existence in the world that occur in a predictable successive order.[5]

Graves' work, we propose, is relevant for Cognitive Innovation as it demonstrates traces of recursion at work and also demonstrates the link to societal processes and community knowledge. It is a rich qualitative account of what Cognitive Innovation—a shadowless structural description—leaves behind, so to speak. Graves' model shares with the model of Cognitive Innovation the aim to account for development from more primitive levels or states to more sophisticated levels or states. Graves' model does this by suggesting a particular direction in the spiral of development of human nature, whereas the model of Cognitive Innovation suggests bootstrapping mechanisms by which development takes place. Whether the latter qualifies for the label of a metatheory is debatable, but at least Cognitive Innovation lends itself as a useful supplement to enhancing self-reflexivity in metatheoretical frameworks like Graves' in a concise way.

[5] Graves' work (particularly his taxonomy of developmental levels) has been popularized by Beck and Cowan's (2005) work on Spiral Dynamics and Ken Wilber's (2000) work on Integral Theory.

Conclusion

The pragmatic value of the concept of Cognitive Innovation to the academic discourse on creativity (and other fields) will stand its test in years to come. It is tempting, both to proponents and reviewers of the concept, to elaborate on possible meanings suggested by the semantic load of its two constituting terms, not least because many concepts in the history of cognitive studies appear to be closely related, named similarly, or both. However, subsuming too many principles under the concept—a likely consequence of opening it up to fit existing discourses of various disciplines—comes with the risk of diluting its semantic span. For this reason, we have suggested that Cognitive Innovation ought to be thought of more in terms of a metatheoretical framework than as a concept. While increasing the accessibility of Cognitive Innovation to a wide audience is in line with Denham and Punt's aspiration to have it provide “a theoretical and practical platform from which to explore disciplinary differences in our understanding of creativity” (Denham & Punt, 2017, p. 184), it is potentially confusing to propose what seems to be a semantic chameleon as a conceptual demarcation from creativity. In addition to pointing out this dilemma (without attempting to solve it), we have highlighted a few aspects of sense-making and affordances of the concept that we think future investigations should examine in more detail.

While Denham and Punt (2017) do not directly propose a method to integrate their different disciplinary specialisms by which they approach and discuss Cognitive Innovation, their individual horizons clearly intersect and seem to be within the reach of integration or fusion. It seems therefore as if the challenge of promoting Cognitive Innovation as a research object lies not so much in the description of the concept, but rather in how to study and write about it in a transdisciplinary manner. We have outlined a few ideas on temporality, interdisciplinary balancing and metatheories that we believe are important to consider in more detail in future enquiries and developments of Cognitive Innovation to navigate analytical operations in the muddy waters of conceptual territory.

Acknowledgements

We thank Sue Denham and Witold Wachowski for their constructive feedback in both writing and discussion. This research was sponsored by the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under the REA grant agreement no. FP7-PEOPLE-2013-ITN-604764.

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AVANT, Vol. VIII, Special Issue
ISBN: 978-83-944622-04-6 avant.edu.pl/en
DOI: 10.26913/80s02017.0111.0001

Our GIFT to All of Us: GA(Y)AM

Preface

This special issue of AVANT is all about Cognitive Innovation. It is not about CogNovo, the interdisciplinary and international doctoral training programme that produced three different Off the Lip events. It is not about Off the Lip 2017, the novel symposium format we developed to collaboratively create a publication resulting in this special issue of AVANT. It is not about the seemingly heterogeneous collection of papers that follow this preface. *Collaborative Approaches to Cognitive Innovation* required something else, something we are starting to capture in the four GIFT principles. While this special issue is not solely about CogNovo, Off the Lip events, or the content of the following submissions, all these aforementioned elements were necessary to shape our current understanding of Cognitive Innovation, the very process which led to numerous publications, exhibitions, and events during the past three years. In a sense, all of our previous endeavours have culminated in this collection of 26 distinct pieces of work, yet we hope and believe that this special issue also marks a beginning. Let us explain.

Similarly to you reading this article right now, most of us joined the work on Cognitive Innovation *in medias res*. A unique transdisciplinary strategy was already being discussed when the doctoral training programme CogNovo formed around it. At that time, it seemed that CogNovo was born out of the desire to build a *multidisciplinary* team, to formulate *interdisciplinary* research questions, and aiming "to be truly *transdisciplinary*" (Denham, 2014, p. 202). Each of the 25 CogNovo research fellows, selected from a large cohort of applicants with a diverse range of backgrounds, were assigned to a team of academic supervisors and industrial partners (for more details, see Maranan, Loesche, & Denham, 2015). In addition to the doctoral training and through several workshops and symposia, spontaneous collaborations were triggered; project-related groups that formed and disbanded, with the roles of each individual changing over the course of CogNovo. We realise now that these dynamics and their implications reflect one of the necessities identified by Choi and Pak (2006) in their literature review on transdisciplinarity, to "transcend the disciplinary boundaries to look at the dynamics of whole systems" (p. 355), but this discussion would take us beyond the scope of this preface. Besides observations of the process, our results can also be traced through the generated artefacts, for example the texts written from the angle of multiple disciplines about the shared topic of Cognitive Innovation transcending into new knowledge—some of which are collected in this special issue of AVANT.

Cognitive Innovation has been described as a self-referential and incremental process that changes itself. Denham and Punt (2017) have given it a functional form, mapping the accessible knowledge of the environment, the individual, as well as their mental processes through these same mental processes onto themselves. In the first Off the Lip in 2015, Blassnigg (2015) linked this to Bergson's merging of memory and image as a "dynamic process within the mind in its constant self-creation in osmosis with its enaction in the given environment" (p. 17) As a result, the engagement with CogNovo not only changed the knowledge about Cognitive Innovation, but it also must have changed the group, changed the individuals involved, and changed the research process itself—a process of Cognitive Innovation as well. In summary, one might argue that research is changed by research itself and as such, cannot be planned in full at its outset. This leaves the question of how such a dynamic process can be understood, not to mention researched?

The GIFT of Improvisation

Our inspiration for thinking about research in such a dynamic and open setting comes from improvisation practice. Improvisation has been described as a vivid practice in the arts, which highlights the collaborative settings, openness, ongoing exploration, and reinforcement of the creative process. The bases for improvisation are curiosity and the embracement of surprise. Improvisation focuses on the process rather than the outcome; it welcomes uncertainty and understands progress as a dynamic change. Outcomes appear through (and in) the process of doing, without clear initial expectations of results. We propose that transdisciplinarity can be understood and framed as improvisational research. We consider the following four main principles to contribute to this type of research:

> **Generosity**: Share ideas, constructive criticism, and reflections, to allow knowledge and methods to develop, and perspectives to adjust. Share as much as you can and be generous enough to acknowledge when the time is not right for an idea. Every contribution, from any individual or discipline should be considered of equal eligibility. Be curious about their knowledge and methods.

> **Interdependence**: Use and establish links between partners, research questions, and solutions from different disciplines. Improving the accessibility of your language and ideas reflects a capability to generalise, not to simplify concepts. It allows you to share the perspectives and principles of a discipline, find the connections to knowledge from other fields, and establish a common

ground with the others. Anticipatory planning cannot account for inputs from all participants, instead implement a "rolling ball" strategy and embrace associations that allow reshaping ideas. The weight of the influences that shape your project will change throughout the different phases of the project.

Free exploration: Allow time for exploration and experimentation with different approaches. Allow successes and failures to inspire the next step and allow input from others as well as coincidences to influence your contribution. It is important to embrace the risk that comes with this approach.

Trust: Participation and contribution requires trust. Trust is not built on promises, but it needs time and action to grow; trust that everyone is contributing as much as they can. Respect the improvisational space and all individuals who share it with you, and acknowledge the origin of ideas.

Improvisational practice does not replace planning and it certainly does not replace preparation or research rigour. On the contrary, improvisational time and space require explicit attention and rigorous planning. Having clear spatial and temporal constraints on a collaborative process allows individuals, and the group as a whole, to adjust their commitment between sessions according to previous experiences and constraints outside the improvisation. These boundaries act as a safety net that allows unconstrained application of the other four principles during improvisation.

GIFT: Current Version

During CogNovo, the organisation of events changed over time, culminating in this year's Off the Lip 2017. The novel format of a collaborative, feedback-based Off the Lip 2017 symposium leading to this special issue was successful beyond our expectations. We invited speakers to come with "almost ready" papers that they would consider publishing in this special issue. Once we received all submissions and to ensure high quality of feedback, we asked each of the authors to write a response to one or two other submissions. During the event, these responses were presented just after the papers, before opening the discussion and questions to the whole audience. We designed the event as a single track with extended "social time." These longer lunch breaks, shared breakfasts, and evening events served as an informal platform to exchange ideas. They emphasised the personal interactions and they also ensured that each submission received adequate feedback. The principles of GIFT were implemented inherently and implicitly yet some of them were identified in the discussion with all delegates towards the end of Off the Lip 2017.

If Cognitive Innovation is, as suggested, the driving force behind the research we have practiced within CogNovo, then this practice is not just the result of the knowledge of the individuals of the extended network of CogNovo and the environment we are situated in. It is, at the same time, an aggregated result emerging from all previous events and collaborations, a fleeting temporal manifestation, and a foundation for future iterations. Even through writing and reading this text, we will change our and your future practices. Therefore "GIFT Ain't (Yet) A Manifesto," but we invite you, the reader, to join us in developing the idea further.

Earlier in this text we articulated the hope that Off the Lip 2017 and these texts will not just be the climax of the doctoral training programme CogNovo.eu, but rather abeginning. Concretely, we would also like to announce the beginning of the CogNovo Foundation. If you enjoy or want to criticise our approach, if you want to engage or want to grow these ideas into a "Manifesto," then please get in contact through our website at CogNovo.org. In the meantime, we hope you will find the writings in this special issue both an insightful and intriguing input to the next iteration of your process of Cognitive Innovation.

Frank Loesche & Klara Łucznik
with the OTLip17 Committee:
Susan L. Denham, Hannah Drayson, Kathryn B. Francis, Diego S. Maranan, & Michael Punt

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AVANT, Vol. VIII, Special Issue
ISBN: 978-83-944622-04-6 avant.edu.pl/en
DOI: 10.26913/80s02017.0111.0021

Dance Improvisational Cognition

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Received 5 May 2017; accepted 26 September 2017; published 21 November 2017.

Abstract

Research into group creativity with its dynamic, interpersonal, and multi-perspective character poses many challenges, among others, how to collect data and capture its shared nature. In this paper, we discuss the creative process of an ensemble in dance improvisation as an example of vivid and collaborative creative practice. To identify aspects of improvisational dance cognition, we designed and applied a video-stimulated recall approach to capturing the multiple perspectives of the shared creative process. We tested the method during an improvisational session with dancers, showing how the recordings of dancers' thought narratives and internal states might be used for studying group creativity. Finally, we presented an audiovisual installation *Between Minds and Bodies* that aimed to recreate the dancers' experience and offered immersion into the creative process by accessing individual dancer's thought processes in the improvised performance while watching the dance improvisation.

Keywords: audiovisual installation; dance; group creativity; improvisation; video-stimulated recall method.

Introduction

In this paper we describe the design and application of a video-stimulated recall approach for studying group creativity, and an installation that seeks to recreate and communicate a group's shared creative experience to members of the general public. To do so, we describe three modules we implemented to annotate and observe the creative process in dance improvisation. Each of the three elements "Preparation," "Studio," and "Installation" can be exchanged and used independently. Here they build on one another to provide a conclusive reasoning for decisions we made during the development. Even though we discuss dance improvisation as an example for a creative process throughout the paper, we are convinced that this method can be applied to a range of tasks and activities to observe and annotate participants' behavior in order to gain a better understanding of their cognitive processes.

Preparation

In the first part we explain the steps that led to the implementation of the video-stimulated recall method as well as some technical preparation.

How to Recollect the Creative Process

Finding a solution or even just an approach to an ill-defined problem often requires the exploration of the problem space. One way to understand the cognitive functions involved in creative problem solving is to learn more about the involved processes. These processes are studied, at least in the domain of creative problem solving, by observing divergent thinking as the generation of several intermediate or alternative solutions, and convergent thinking as the attempt to arrive at a single solution (Cropley, 2006). In some cases, finding the solution is accompanied by a Eureka experience or 'Aha!' moment (Bowden, Jung-Beeman, Fleck, & Kounios, 2005). Most divergent, convergent, and insightful thinking tasks focus on the outcome and the generated product. As a result, they provide snapshots in time through artefacts, but they fail to capture the whole process of problem solving.

Verbal protocols have been shown to provide reliable data about introspection on processes (see Fox, Ericsson, & Best, 2011 for a review). Nevertheless, this is not viable in group tasks as participants' verbal reports would influence each other's performance. One way to avoid this is to assess the process after it has finished and the solution has been found. However, it is unlikely that the memory of the process accurately reflects what happened when solving the problem. Even if people are asked immediately after solving a problem, it is difficult for them to recall exactly what happened, even more so if they experienced an 'Aha!' moment, which has the tendency to be the dominant memory of a problem-solving process, potentially masking other memories. For example, Danek, Fraps, von Müller, Grothe, and Öllinger (2012) showed that people more easily recall magic tricks they discovered themselves through an 'Aha!' moment than those for which they failed to solve or were told the solution. To aid the memory of the problem solvers and help them remember the thoughts they had had, Glăveanu and Lahlou (2012) used recordings of the process. Video recordings are particularly useful if the problem solving process generates artefacts or is accompanied by intermediate output, for example writing, movement, or sound. When considering possible tasks, the given problems should be solvable within a limited time for pragmatic reasons regarding observation and memory recall. Taking these constraints into account and with the aim to investigate the creative process in contemporary dance, we decided to observe dance improvisation as a vital creative practice in the field of dance. This approach makes it possible to capture both the process and the results of the creative process at the moment it is created (Sawyer, 1999).

Observing Process

Improvisation in contemporary dance serves two main purposes: it is an open-form performance practice and it is widely used for generating novel movement material for choreographic phrases (Carter, 2000). If we consider dance as an ill-defined problem, improvisation, with its unplanned, open-ended form, gives dancers a chance to explore movement beyond habitual patterns; they can discover unknown possibilities and bodily solutions (Forsythe & Haffner, 2012). Creativity in this understanding of improvisation is dynamic: the solution for given problems may occur at any time, while listening to a task or even after the improvisation is finished, and can be triggered by movements or new problems discovered during the dance. 'Aha!' moments—sudden instances of solving a problem in a creatively successful, coherent improvisation piece—come unexpectedly with movement, rather than as a prediscovered idea (Blom & Chaplin, 1988). As dancers commonly use their bodies and movement as tools with which to experiment (Kirsh, 2011), new ideas appear through dancing while dancers think in a mostly non-propositional way.

In interviews with dancers about how they improvise, Nakano and Okada (2012) show that dancers interact with various stimuli from both internal and external sources: they react to imagery, sensations, and feelings that they entertain during the performance, as well as to music, space, and their audience. Dancers make movement choices by responding to these stimuli and organize their movement extemporarily, using techniques such as switching and changing speed, as well as imagining themselves from the third person perspective (Nakano & Okada, 2012). Their study gives a general understanding of dance improvisation practice; however, it does not examine the dynamics of the process as it happens as the findings are based on dancers' general recollection and beliefs about their practice.

In an in-depth analysis of solo performance, De Spain (2003) explored improvisational cognition using the momentary awareness sampling method in a series of solo improvisation sessions with experienced movement improvisers. He recorded momentary awareness reports by asking improvisers to 'report now' what was in the front of their mind at random moments of the improvisation. Similarly to Nakano & Okada's (2012) results, he found that improvising awareness could be focused on internal sensations, especially proprioception (the feeling from the dancer's body), mental images related to the body, (like "foot exploring space… have eyeballs in my toes"; De Spain, 2003, p. 31), emotional states, or an aesthetic reaction to one's own movement. At the same time, improvisers' awareness is engaged with the external world, which they sense through seeing, hearing, tactical sensations of skin, etc. Attention can also manifest as visible movement because of the necessity to direct and focus the act of sensing—to turn the head to see or hear in reaction to the surrounding environment, etc. Furthermore, De Spain (2003) pointed out the importance of memories, especially kinaesthetic ones, which might be echoed in movement choices. Finally, the role of awareness of intentionality could be direct ("I'm walking") or indirect ("It moved me"), acting as a filter for movement choices and a feedback loop regarding the whole process.

The current research aims to extend De Spain's (2003) approach beyond the individual, focusing on dancers' improvisational cognition as well as the group dynamics in a shared creative process of group improvisation. The particular focus on group interaction originates in the social aspect of dance practice, as solitary processes are rather unusual in dance creativity in general (Stevens, Fonlupt, Shiffrar, & Decety, 2000). The exploration in this paper is predominantly experiential, as captured in the audiovisual installation *Between Minds and Bodies* (see section "Installation"); however, the methods elaborated through this paper have successfully been deployed in another instance of this project. Qualitative and quantitative studies on shared creativity and flow experience in dance improvisation using a similar method have been published in Łucznik (2015, 2017).

Studio

This section consists of three parts: we explain the general setup of the study in "Setup," the second part explains how the process is recorded, and the third demonstrates how we gathered feedback from the participants using the video recall method.

Setup

Group improvisation brings the richness of interactions and interdependence of choices made by the dancers within a group. We expected that the distributed character of practice would shift dancers' interest from a solo-oriented focus to a collaborative, co-creative, and group-oriented process. One of the challenges was to find the right way to record the multiple perspectives of the group process. A simple adaptation of De Spain's (2003) method of talking out loud proved to be unsuccessful in group settings, as dancers got distracted and influenced by others' comments.

In the field of ethnography, Glăveanu and Lahlou (2012) explored the use of a subjective camera (subcam) to obtain a first-person audio-visual recording of creative action. The collected video material was then used to assess the subjective experience of the participant through a confrontation interview using excerpts from the recording. This approach enabled microscopic, decision-making description of creativity at the levels of both process and content. We considered adapting the method to document creative processes in dance, but quickly realized that it would be highly constrained by the practice. Firstly, dance is a dynamic activity with frequent head movements and changes of levels and focus of the field of view. The image obtained from a body-mounted camera would be too puzzling to watch and too difficult to interpret. Secondly, dancers rely not only on direct visual cues, but also on peripheral vision and other senses like hearing, kinaesthesia, and touch (De Spain, 2003). Finally, even with the current level of miniaturization of electronic devices, the size of available cameras still obstructs and constraints the movement of dancers, particularly in improvisational practice.

Following up on this, we suggested a video-stimulated recall method (Rowe, 2009) to capture dancers' thought narratives and awareness throughout the dance improvisation. A similar method was used in describing the thinking process underlying jazz improvisation (Norgaard, 2001), in which an audiovisual recording of a just finished improvisation was used as a basis for the interview. While watching the video of their performance, musicians were asked to narrate their conscious thoughts, considering questions such as "Where did that come from?" These works inspired our idea of collecting data on participants' introspection on the creative process through verbal protocols (both delayed and outside the group process) and with support for the participants' memories through video-recordings.

The present adaptation of the video-stimulated recall method is implemented with immediate playback. Since we were interested in individual verbal narratives on the group process of dance improvisation, we wanted to give our participants the chance to play the video recording at their own speed and to pause and resume at will. Additionally, we explored the possibility of annotating cognitive states experienced by dancers during the improvisation process. For one derived research study, which looked into cognitive components that enhance creativity (Łucznik, 2017), we asked the participants to report their experience of flow (Csikszentmihalyi, 1975, 1990) using this annotating feature.

The technical setup for the video-stimulated recall method needed to be portable, simple to apply to a flexible group size, and easy to operate for a single researcher. To provide the dancers with a familiar interface, we decided to use tablets with an HTML5 touchscreen interface for the video playback and feedback collection. We used a Wi-Fi network and a local web server to quickly transfer the recently recorded video material to all connected tablets and collect the participants' responses in one central location.

In our setup, we did the video recording (Figure 1a) with a stationary video camera on a tripod with a wide-angle lens, thus capturing all the group's actions from a third-person perspective. In this setup we transferred the video recording on an SD memory card (Figure 1b) to the computer. A laptop (Figure 1c) that was capable of transcoding the videos and running the server software also needed to be set up in the studio. For better control over the signal strength and available bandwidth, we chose to provide our own portable hotspot (Figure 1d), which gave us full control over network authentication of the laptop and tablet devices. Finally, the browsers on the tablets were pre-configured to the URL of the video-stimulated recall application.

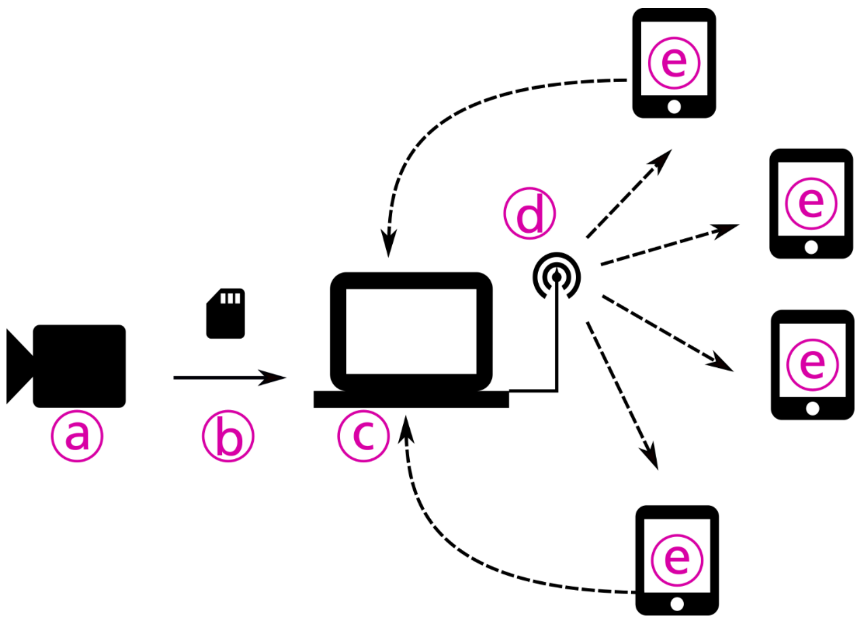

Figure 1. Schematic setup setup with (a) video source, (b) transport to server, (c) WiFi multicast (d) to tablets (e).

Capturing Improvisation

To capture the creative process in dance improvisation, we invited dancers to take part in a workshop. We asked them to engage with several improvisational tasks and reflect on their experience using our video-stimulated recall method of the creative process. The improvisation ensemble depicted in the supplemental material consisted of four dancers: Ellen Hunn, Kevin French, Saurav Rai, and Klara Łucznik (one of the authors of this paper). In the workshop, the dancers improvised together as a group to a score, which provided a starting point for the improvisation (e.g., “Let your ears listen to the sounds—of your body, of others, of space. Let your feet sense the floor . . . Let all your senses open and lead you for the next few minutes in the dance”). Each score lasted around 4–5 minutes and was ended by the experimenter. The improvisation was followed by the capture process of the video-stimulated recall procedure. This procedure was first perceived as unusual, but quickly all dancers got used to narrating their process. Moreover, they found the procedure interesting and insightful for their own practice.

The camera recording was started and stopped manually at the beginning and the end of the improvised score. Once the recording had stopped, the SD card with the video recording was moved to the computer and a prepared computer script was run in order to fulfil two tasks. Firstly, the high-quality video recording was transcoded to a low bandwidth stream. Secondly, the script started a web server on the local Wi-Fi network. In the first step, the Handbrake[1] software transcoded the latest video file from the SD card to a stream with a resolution of 640x320 pixels, a quality rating of 18, a peak-limited frame rate of 30, and an AAC audio codec with 96kbit/s. The transcoding took about a third of the recorded time using an i7 processor (Haswell generation), for example 1min 30s for a 5-minute improvisation. This step generates a video file that could be transmitted to a large number of clients with the given setup, independent of the type and setting of the video camera. While the video was transcoding, the dancers received tablets with headphones and a short explanation about the next step. Through the web application on the tablet, participants had full control of the playback of the video stream and were also able to report their state of flow using an on–off button. The current position in the video stream and the status of the reported flow states were shown on a timeline. These features were implemented in HTML5 using JavaScript for interactive elements and communication with the server.

The local web server (implemented using node.js[2]) on the laptop was able to serve the web application and stream the video file simultaneously to multiple clients at high-speed while collecting status reports and feedback from the individual participants. The latter included the status of the video playback; for example, when participants started playback, skipped forward or backwards through the recording, and paused the playback. This information was available for use afterwards to

[1] “HandBrake – The open source video transcoder,” available at https://handbrake.fr/ (last access: 2017-09-15)

[2] “node.js,” available at https://nodejs.org/en/ (last access: 2017-09-15)

synchronize voice reports with video content. The system also recorded and visualized a single tap on the flow button, which changed the reported flow state at the current time in the video from flow to not-flow and vice versa (Figure 2).

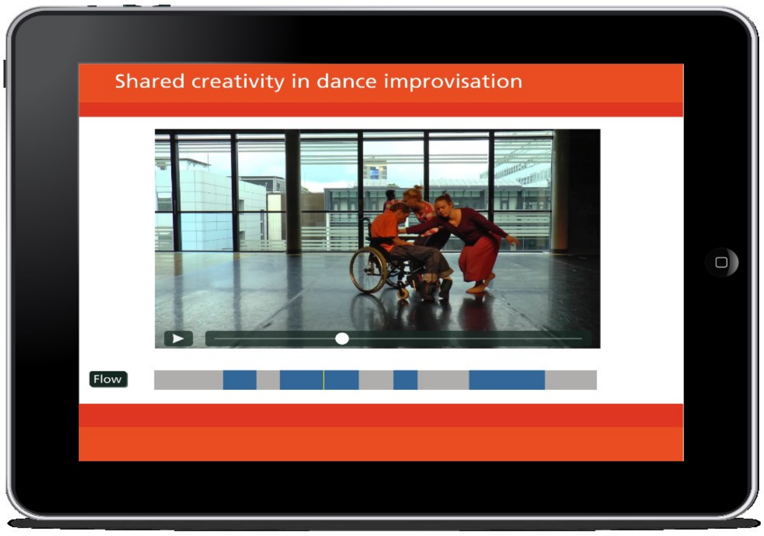

Figure 2. A video simulated recall method—tablet view.

Using the same programming language for client and server proved to be useful for a quick turn-around during the development and prototyping of the video-stimulated recall method. Also, using an HTML5-based client deployed from the central we server reduced the complexity of the technical setup and the interactions that were necessary from the researcher during the experiment.

The voice reports were recorded through separate audio recorders. Due to verbal communication limitations, one of the dancers, Kevin, provided a detailed recollection in written form later during the day of the improvisation. Kevin's condition limits his ability to speak, but he can rely on great memory skills. Since each feedback was given individually and video recorded to support the recall process, this change of procedure was not expected to influence the outcome of our research interests.

The video-stimulated procedure for recollecting the creative process and flow states was found to be fruitful, as measured in collected narratives of several collaborative dance processes that were used to gain further insight into creativity (Łucznik, 2015) and the nature of flow experience in dance (Łucznik, 2017). Finally, the method allowed us to collect materials for the audiovisual installation presented below.

Installation

One recorded instance using the video-stimulated recall method was showcased as *Between Minds and Bodies* during the Off the Lip 2017 event at Plymouth University. The video recordings are also available in the supplementary material of this article. This section provides a description of this installation.

Between Minds and Bodies

The audiovisual installation *Between Minds and Bodies* consists of video materials of an improvising dance ensemble accompanied by dancers' narratives of their creative process obtained from an improvisation workshop. In this particular piece of work, our interest lies in understanding the creative process in dance through experiencing the dancers' thinking processes in improvised performance. The setup includes a large screen and four pairs of headphones. While the group improvisation of the dance ensemble is presented on the screen, each pair of headphones plays back the voice recall of the creative process of a particular dancer, with the other voices playing in the background at a lower volume. The combination of the screen and the four individual headphones allowed the audience to engage with the multi-perspective interactive aspect of group creativity. The four different narratives and their combination reveal the co-agency of dance improvisation in each moment of creation. A spectator has the opportunity to experience and be immersed in the creative process of any of the dancers at any moment during the improvisation, gaining insight into the dancers' choices, interests and thoughts, along with the visual output of the group dance.

Watch the installation at: https://doi.org/10.26913/80s02017.0111.0021

As one of the spectators, Aska Sakuta, shared:

> As an intuitive response to this setup, I decided to look at the screen, listen to the sound, and walk around, all at once. From the headphones flow multiple streams of consciousness, narrated by different voices, some louder than others. Soon, I start noticing subtle consistencies between what is being spoken, and what is being shown on the screen; a voice would say "I just lean in," right as someone on the screen leans on another body, and another voice would say "I feel the floor," as I notice someone's foot sliding across the floor. For a moment, I decide to take off the headphones and watch the video on its own. Remnants of the voices echo through my consciousness, as I notice some motifs that have carried on since they were first presented. I place the headphones back on my ears and notice that the narrations have moved on to a completely different theme—my attention quickly synchs to the narration, as my eyes start to focus again on what is being spoken. This time, however, my body responds to the "movement words" that appear in the narration—"entre," "walk," "balance," "rest"—I am seeing, hearing, and doing the movements all at once, and I feel as though I am the movers themselves, switching from one mover to another, based on the most dominant voice in the recording.

Conclusions

In this paper we describe an end-to-end approach to identifying salient aspects of group creativity by designing a method to capture these aspects. In addition to the technical aspects of this process, we also describe a way of sharing these experiences with members of the general public in an exhibition. The current research has a mostly experiential character of audiovisual installation; the collected material enables third parties, such as a spectator at the installation or a researcher interested in the creative group process, to enter the improvisational process of dancers by engaging with a video recording of improvisation. The multiple perspectives delivered through audible layers of dancers' thoughts from a single group improvisation reveal the complexity and interdependency of a creative group process.

The video-stimulated recall method presented in this paper might be used in the wider context of group dynamic research. We suggest using this method if participants' introspection on processes is of interest. In particular, the video-stimulated recall method has shown to be useful for processes that are accommodated by the generation of intermediate artefacts (Łucznik, 2015, 2017). Tablets offer an easy to administer and time-economic way of capturing the experience and internal states of group members.

Acknowledgements

The authors would like to thank Thomas Wennekers and Aska Sakuta for their detailed feedback, and the delegates at Off the Lip 2017: CogNovo Colloquium on Experiences and Applications of Cognitive Innovation for the interesting and open discussion.

The source code and additional technical descriptions are available on request via the corresponding author.

This work was supported by Plymouth University and CogNovo (FP7-PEOPLE-2013-ITN-604764), a project funded by the EU Marie Skłodowska Curie programme.

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Response to "Dance Improvisational Cognition" by Eugenia Stamboliev

The paper provides a very thoughtful insight into its research interests and the challenges of understanding creative dance practice, especially in the context of improvisation and group creativity. It points to the difficulties of recording or explaining the creative and often embodied process of dance improvisation. As such, dance improvisation is considered an expressive bodily enactment that does not follow a preplanned choreography (Nakano & Okada, 2012); therefore, it can only be discussed *post*-practice in the form of a reflection on movement.

The paper does well in positioning the viewer in the process of dance improvisation practice. However, the paper's understanding of the observing viewer of the dance practice could gain from the valuable perspective of the 'participatory observer' provided by anthropology (Jorgensen, 2015), since this position is not a neutral one, but interferes with the observed dance improvisation.

The paper unravels issues with first-person video recording of dance practices as a method of exploration and suggests, with reasonable arguments, why 'video-recall methods' could be a better way to research the process of improvisation.

The only major problem I see (and I assume the authors also do) is that the verbalization of a non-verbal, embodied process constitutes an issue for many artists or creative practitioners. Asking dancers about their post-practice and rationalized movements could lead to a blurry, and maybe inflated explanation of a process that in fact seems less cognitive or rational and much more embodied and non-verbal.

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AVANT, Vol. VIII, Special Issue
ISBN: 978-83-944622-04-6 avant.edu.pl/en
DOI: 10.26913/80s02017.0111.0016

(Not So) Dangerous Liaisons:
A Framework for Evaluating Collaborative Research Projects

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Received 13 May 2017; accepted 30 September 2017; published 21 November 2017.

Abstract

With advances in research environments and the accompanying increase in the complexity of research projects, the range of skills required to carry out research calls for an increase in interdisciplinary and collaborative work. CogNovo, a doctoral training program for 25 PhD students, provided a unique opportunity to observe and analyze collaborative processes. We propose a process-oriented framework for understanding research collaborations along two dimensions: interpersonal and project-related. To illustrate the utility of this process-oriented framework, we apply the framework matrix to several collaborations that emerged within the CogNovo program. The framework that we introduce has several advantages over existing metrics. Firstly, we offer a process-oriented—as opposed to product-oriented—evaluation of interdisciplinary and collaborative endeavors. Secondly, we propose a means of assessment that preserves the distinctive profile (or "fingerprint") of a given collaborative project, thus capturing the uniqueness of each project and its environment.

Keywords: collaboration fingerprint; collaborative framework; group work; interdisciplinary research; organizational team performance; research assessment.

With achievements increasingly arising from teamwork, "collaboration" has acquired a vital role in organizational, educational, and research contexts (Larivière, Gingras, Sugimoto, & Tsou, 2014). In particular, *research collaboration* has received increased attention, with many leading institutions arguing that complex contemporary issues (such as health, environment, and mobility) require solutions that combine insights from different disciplines (National Academies, 2005; as cited in van Rijnsoever & Hessels, 2011). The complex nature of these issues increasingly necessitates that knowledge and solutions can be combined from multiple disciplines (Buanes & Jentoft, 2009). Research collaboration has been described in various contexts and by various approaches, with a lack of consensus over its definition; this is why it is often defined under the umbrella term "collaboration" (Bukvova, 2010). What "interdisciplinary collaboration" entails has remained particularly unclear (Huutoniemi, Klein, Bruun, & Hukkinen, 2010).

Nevertheless, a common theme among various collaborations is that they involve engagement and interaction between two or more people at one time or repeatedly, in order to achieve a common goal (Patel, Pettitt, & Wilson, 2012). Identifying which factors constitute "successful" interdisciplinary, multidisciplinary, or transdisciplinary[1] collaboration and what participating members can do to nurture these is "of significant theoretical interest" (Mansilla, Boix, Lamont, & Sato, 2012, p. 2). Beyond theory, shedding light on this "black box" (Kurtzberg & Amabile, 2001) has also become an increasing priority for funding bodies and research in industry (Mansilla et al., 2012).

How to operationalize research collaboration is a topic of debate (Katz & Martin, 1997). Various approaches have been adopted in order to evaluate research collaborations, including bibliometrics, interviews, observations, experiments, and social network analysis (Groboljšek, Ferligoj, Mali, Kronegger, & Iglič, 2014). Measuring publications through co-authorship evaluation, where publications become the ultimate indicator for collaboration success, is particularly common (Bukvova, 2010). More specifically, the mean number of authors per paper (termed the "Collaborative Index", Lawani, 1980; as cited in Savanur & Srikanth, 2010), the proportion of multi-authored papers (termed the "Degree of Collaboration", Subramanyam, 1983), or a combination of these (termed the "Collaboration Coefficient"; Ajiferuke, Burrel, & Tague, 1988) have been used as metrics to assess the scope of collaboration across fields or disciplines (Savanur & Srikanth, 2010). However, an important point that is often overlooked is that not all research collaborations result in co-authored publications, nor are all co-authorships born out of collaborations (Bukvova, 2010).

[1] Although often used interchangeably or without clear definition (Lawrence, 2010), here we adopt the following definitions. Interdisciplinarity "unites" and "synthesises" links between disciplines to form a "coherent whole," multi-disciplinarity draws on information from multiple disciplines but stays within disciplinary limits, and transdisciplinarity brings disciplines together in new contexts and transcends existing disciplinary boundaries (Choi & Pak, 2006, p. 351). Of course, these categories are not always mutually exclusive given the complexity of many research projects (Klein, 2008).

In addition, the publication of interdisciplinary research appears to be more difficult, resulting in a lower number of interdisciplinary publications and co-authorships. Bruce, Lyall, Tait, and Williams (2004) identify the lack of opportunities to publish interdisciplinary results in high-ranking journals as a discouraging factor to work on interdisciplinary topics.

Evaluating collaborations using product-based approaches, in which outputs of collaborations (i.e., co-authorships) are accepted as indicators of collaboration success, has the advantage of using easily accessible and measurable data (see Groboljšek et al., 2014, for a review). However, these approaches often undervalue the importance of the collaboration process. In their literature review, Aboelela et al. (2007) explored the different views on interdisciplinarity in order to compose a theoretical definition of interdisciplinary research. Key components of interdisciplinary research from the literature included: covering qualitatively different research disciplines; creating a continuum of collaboration which varies from brief communications to mutual integration; establishing a platform for cooperation, interaction, communication, and sharing. In fact, this latter component is considered critical in the majority of interdisciplinarity definitions (Aboelela et al., 2007). As such, a process-based framework, which focuses on what Callard and Fitzgerald call the "choreography" (2015, p. 80) of cooperation and integration between group members, could offer valuable insights for understanding and evaluating research collaborations. Therefore, while we cannot deny the value of collaborative outputs, in the present paper, we focus on the process of collaboration and the dynamics of interdisciplinary integration. We interpret examples of collaborations within the same organization on two dimensions: interpersonal and project-based. To capture and evaluate these collaborations, we propose a process-focused matrix. We present several example studies of collaborations that were fostered within the interdisciplinary CogNovo project[2] (Maranan, Loesche, & Denham, 2015), and demonstrate how collaboration success can be analyzed by exposing the processes that occurred during collaborative work.

Process-Oriented Framework

The current framework incorporates observable indicators of collaborations through two main strands: 1) Interpersonal dimension: how the social dynamics, as well as the individual research interests and contributions, shape group collaborations. 2) Project dimension: what specific project tasks and steps need to be completed in order to reach an outcome. Field knowledge, skills, and project commitment are integral to this dimension.

[2] CogNovo is an interdisciplinary doctoral training program jointly funded by the Marie Skłodowska Curie Actions and Plymouth University, comprising a network of diverse researchers from various disciplines, including Psychology, Computational Neuroscience, Robotics, Arts and Humanities.

Of course, any given collaboration will have external conditions for success driven by institutional contexts (Mansilla et al., 2012). The conventions and expectations of both academic fields and funding organizations will inevitably contribute to the collaborative environment and both the interpersonal and project dimensions of any given project. The institutional context initiates, supports, and funds the collaborations and thus has a significant impact on the overall success of the collaborative endeavor. The examples described in the present paper include projects that were all completed within the same institutional contexts. As such, at the end of this paper we offer suggestions on how the process-oriented framework might be extended and adapted to take into account other institutional contexts.

Interpersonal Dimension

Within our process-oriented framework, the interpersonal aspect of a collaboration can arise in three different ways: 1) *Mutual collaborations*: every participant contributes to the collaboration equally and the contribution from different disciplines is weighted equally. Collaboration results in similar outcomes for all involved disciplines. 2) *Assisted collaborations*: the project is led by one discipline and collaborators from other disciplines assist by providing specific knowledge. Collaboration results in progress in the main discipline. 3) *Emergent collaborations*: these collaborations do not require a specific domain knowledge. Collaboration may occur on a primarily social or pragmatic level (e.g., departmental colleagues organizing a research seminar series) involving no particular discipline, or the collaboration may result in progress in a new (or emergent) discipline.

Project Dimension

All collaborations involve a project dimension, where certain tasks must be accomplished in order to achieve the desired outcomes. This dimension involves coordination between the participants' knowledge of domain(s) and relevant skills. For the projects evaluated within CogNovo, we identified the following primary steps: 1) *Objective & Research Question*: formulating objectives and research questions; 2) *Experiment*: formulating and/or carrying out methods; 3) *Analysis*: formulating and/or carrying out analyses; 4) *Communication*: formulating and/or carrying out dissemination strategies to communicate collaboration outputs (e.g., writing papers). Even within the same context, these steps will have different importance and may even be skipped entirely depending on the implementation, aim, and success of the project. Importantly, although stages are described linearly here, the reiterative and adaptive transfer from one stage to another can be both dynamic and unpredictable. For example, it is likely that project objectives and research questions will be frequently revisited and revised at multiple times during a project lifecycle.

Process-Oriented Framework Scheme

According to the process-oriented framework, each collaboration can be evaluated through the interpersonal and project dimensions on a point-based system. We propose that the four stages of a project should be measured independently. In the first stage, *Objective & Research Question*, a research question is generated and a method is explored (and potentially tested). If the research question derives from and seeks to fill a gap in literature in two or more distinct domains, the collaboration can be seen as mutual. Instead, if the gap can be filled by applying knowledge or a method from one of the involved domains, the collaboration is assisted. Finally, if several researchers identify a potentially interesting topic outside of all their domains and create a question and method to answer it, the collaboration could be classified as emergent. Each project stage can be simultaneously mutual, assisted, and emergent to different degrees. An initial scoring of the project can be done in accordance with these three categories: we suggest that the sum of the categories for each row should be 100%. For example, if a participant wants to express that a project was ⅔ mutual, ⅓ assisted, and not emergent at all, (s)he would score it as 67% mutual, 33% assisted, and 0% emergent.

The second stage, *Experiment,* includes any kind of data collection that contributes to answering the questions identified in the first stage. This type of data collection can be either grounded or contribute to several domains, and therefore it can be categorized as mutual. If the methodology is borrowed from one domain to address the data collection from a second one, this could be classified as assisted. Finally, if the method is taken from another line of work in which all participating researchers have only lay-people knowledge, this project would lay in the emergent collaboration category.

The third stage, *Analysis*, involves any kind of data processing that transforms the data collected in the previous stage into knowledge of some kind. The *analysis* may be driven by conventions prescribed by a single discipline. For example, in the sciences, both quantitative and qualitative methods could be applied at this stage, while in the humanities historical methods might be adopted, and in philosophy, conceptual analysis might be favored. It is also possible for the *analysis* to incorporate analytical procedures that combine several disciplinary approaches or that construct approaches that transcend traditional methods bound by a single discipline. Note that the rule of distributing 100% across the three columns also applies here.

At the final stage, *Communication*, results are communicated to others through various ways such as poster presentations, talks, papers, or even through chats and other forms of informal conversation. If a journal covers two or more research areas that the project is situated within, the communication can be seen as mutual. Instead, if the results are communicated at a specific conference but calling for support from a different domain, this communication would belong to the assisted category. Finally, communications such as open science, code repositories, or public engagements events, are considered primarily as belonging to the emergent category.

In parallel and independent of the measures collected for each stage, the importance (or *weight*) of the stage itself can also be rated. For a project that aims to generate new research questions, the main focus might be on the first and, to a lesser extent, on the fourth stage. For projects that focus on novel analysis of existing data, the second and third stage would receive more weight. The four stages cover the lifecycle of a project, thus the sum across all stages is 100%. For example, if all stages have a similar weight, then they would each receive 25%. An alternative to rating weights in hindsight is the amendment of stage weights based on the project aims.

Table 1 illustrates an example of this matrix system. In this case, the first step has almost ⅓ of the overall weight (30%). This project has no experimental aspect, thus the data collection method is not considered a valuable contribution by the collaborators. Likewise, the analysis plays only a small role (10%). On the other hand, the communication of the results is rated as the most important part of this project and received a 60% weight in the overall rating. Based on this intuitive rating, an overall rating of 41% mutual, 15% assisted, and 44% emergent could be calculated for this project.

Table 1. Illustration of the evaluation matrix of proposed framework.

	Weight	Classification		
		Mutual	Assisted	Emergent
Objective & Research Questions	30	70	30	
Experiment		(N/A)	(N/A)	(N/A)
Analysis	10	20	60	20
Communication	60	30	0	70
Overall rating		**41**	**15**	**44**

CogNovo Project Collaboration Examples

Example 1: "Bisensorial" (Hack the Brain 2016 Hackathon).

Collaborators: Diego Maranan, Agi Haines, Jack McKay Fletcher, Sean Clarke, Kim Jensen, Ricardo Mutuberria

Disciplines: Design, Music, Cognitive Neuroscience, Computer Science, Psychology, Arts

Objective & research questions: Ideate and prototype a "hack" based on the event theme, "Hacking yourself for better or for worse," that maximizes the skills of the participants and the resources available during the hackathon.

Result of design experiments: A working proof-of-concept of a wearable, neuro-adaptive, vibroacoustic therapeutic device.

Communication: Presented at Hack the Brain 2016 event; exhibited at Off the Lip 2016 public engagement event, Bizarre Bazaar; exhibited at the Cognition Institute Conference; to be presented at the Ars Electronica STARTS event; discussed in PhD thesis (Maranan, 2017).

Collaboration type:

Table 2. Evaluation of Bisensorial Project.

	Weight	Classification		
		Mutual	Assisted	Emergent
Objective & Research Questions	50	80	15	5
Experiment	35	30	70	0
Analysis		(N/A)	(N/A)	(N/A)
Communication	15	75	25	0
Overall rating		**64.25**	**33**	**2.75**

Example 2: BRAMZ (Because youR BrAin MatterZ)

Disciplines: Psychology, Linguistics, Human-Computer Interaction

Collaborators: Ilaria Torre, Frank Loesche, Kathryn Francis, Raluca Briazu, David Bridges

Objective & research questions: The main aim of this project was to develop personality measurements through games. Specifically, to build a mobile phone application in order to implement the games and collect data from experiment participants.

Experiment: Prototypical implementation during Computational Modelling workshop

Analysis: No analysis was conducted.

Communication: Grant application for the "StudentshIP Enterprise Awards 2014."

Collaboration type:

Table 3. Evaluation of BRAMZ Project.

	Weight	Classification		
		Mutual	Assisted	Emergent
Objective & Research Questions	30	70	30	0
Experiment	10	20	60	20
Analysis		(N/A)	(N/A)	(N/A)
Communication	60	30	0	70
Overall Rating		**41**	**15**	**44**

Example 3: Impasse in Conversations

Disciplines: Linguistics, Psychology

Collaborators: Ilaria Torre, Frank Loesche

Objective & research questions: Analyze creative problem solving in social interaction, in focusing in particular on how impasses are overcome in conversation.

Experiment: Choice of conversations, data collection not part of the project.

Analysis: Conversation analysis on freely available corpus of spontaneous conversations.

Communication: paper in *Creativity: Theories-Research-Applications Journal* (Torre & Loesche, 2016); Poster presentation at UK Creativity 2017 Conference (Edinburgh)

Collaboration type:

Table 4. Evaluation of Impasse in Conversations Project.

	Weight	Classification		
		Mutual	Assisted	Emergent
Objective & Research Questions	35	80	0	20
Experiment	20	30	50	20
Analysis	20	50	30	10
Communication	25	70	0	30
Overall Rating		**61.5**	**16**	**20.5**

Example 4: Distorted Dimensions

Disciplines/fields: Social Psychology, Cognitive Psychology, Philosophy, Art & Design

Collaborators: Kathryn Francis, Agi Haines, Raluca Briazu

Objective & research questions: Using moral psychology as a case study, we explored the importance of incorporating considerations from design research into the development of testing tools in the experimental sciences. We further considered how the process of "making" might be utilized as a collaborative tool, nurturing successful interdisciplinary endeavors.

Experiments/outputs/results: An interactive and life-like testing tool was constructed and incorporated in an existing moral decision-making experiment.

Communication: (a) Data were collected during an *interactive installation* with members of the public at OTLip16. (b) The data collected were incorporated into a *scientific publication* (Francis et al., 2017). (c) A *conference paper* exploring the use of "thinking through making" as an interdisciplinary collaborative tool was presented at OTLip17 (Francis et al., 2017.

Collaboration type:

Table 5. Evaluation of Distorted Dimensions Project.

	Weight	Classification		
		Mutual	Assisted	Emergent
Objective & Research Questions	19	38	32	30
Experiment	29	48	33	19
Analysis	21	40	30	30
Communication	31	42	20	38
Overall Rating		**43**	**28**	**29**

Conclusions

Research contributions from large and diverse research groups play a key role in the solution of complex societal problems (Buanes & Jentoft, 2009). Encouraging collaboration between various disciplines results in the sharing of domain-specific knowledge, but also in the emergence of new knowledge (De Stefano, Giordano, & Vitale, 2011), thus providing novel solutions for unresolved age-old problems. Yet, what entails "successful" interdisciplinary collaboration has largely remained unclear (Huutoniemi et al., 2010).

To date, existing attempts to evaluate the impact of interdisciplinary research collaborations have sought to assess product-based outcomes, primarily considering co-authorship as a marker of success (Savanur & Srikanth, 2010). Although these product-based approaches have allowed researchers to accurately quantify the impact of various disciplines within a collaboration (e.g., Groboljšek et al., 2014), they often overlook process-based markers of success. This is significant given that definitions of successful interdisciplinary collaborations encompass process-based considerations including mutual integration, cooperation, communication, and sharing (Aboelela et al., 2007).

In the current research, we formulated a novel framework for evaluating, as well as summarizing, research collaborations. By establishing a process-based framework, we have contributed to the literature by complementing the product-based approaches to evaluating collaborations. By generating a collaborative "fingerprint" for each project, the present process-oriented framework allows researchers to examine the interdisciplinary dynamics within a research group. This is significant for several reasons. Firstly, we can shed light on the "black box" that surrounds the understanding of collaborative processes (Kurtzberg & Amabile, 2001). Secondly, we can use the process-based fingerprint to identify which group dynamics and which types of collaboration are more likely to succeed. This might be done by uniting our metric with product-based markers for success and/or measures of researcher satisfaction.

When considering the institutions, organizations, and funding bodies that support these collaborative endeavors, it is important to note that the collaboration examples described in the present paper were supported by the same institution and, as such, were fostered within the same organizational context. In order to extend our process-oriented framework, we suggest that future research should embrace the flexibility of the stages that we propose, adapting the metric to reflect the aims and constraints of their own organizational and institutional contexts.

Overall and through a detailed look at several collaboration examples that took place within the CogNovo project, we have developed a process-based approach for understanding both the interpersonal and project dimensions of interdisciplinary collaborations. Specifically, we have demonstrated that each collaboration is subject to different priorities and pressures. Thus, individual projects can display a unique combination of interpersonal dynamics and project tasks. Our process-oriented framework and evaluation matrix might be utilized not only to evaluate and provide building ingredients for successful interdisciplinary research collaborations, but also to quantify the impact of these collaborations beyond product-based metrics.

Acknowledgements

We would like to Klara Łucznik and Joan ten Hoonte for their comments on an earlier version of this paper and all participants at Off the Lip 2017: CogNovo Colloquium on Experiences and Applications of Cognitive Innovation for the fruitful discussion.

CogNovo and this study are jointly funded by Plymouth University and the Marie Skłodowska-Curie actions (MSCA) program (FP7-PEOPLE-2013-ITN-604764).

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AVANT, Vol. VIII, Special Issue
ISBN: 978-83-944622-04-6 avant.edu.pl/en
DOI: 10.26913/80s02017.0111.0012

Spectres of Ambiguity in Divergent Thinking and Perceptual Switching

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Received 12 May 2017; accepted 30 September 2017; published 21 November 2017.

Abstract

Divergent thinking as a creative ability and perceptual switching between different interpretations of an unchanging stimulus (known as *perceptual multistability*) are thought to rely on similar processes. In the current study, we investigate to what extent task instructions and inherent stimulus characteristics influence participants' responses. In the first experiment, participants were asked to give as many interpretations for six images as possible. In the second experiment, participants reported which of two possible interpretations they saw at any moment for the same line drawings. From these two experiments, we extracted measures that allow us direct comparison between tasks. Results show that instructions have a large influence over the perception of images traditionally used in two different paradigms and that these images can be perceived in appropriate ways for both tasks. In addition, we suggest that the connection between the two phenomena can be explored interchangeably through three experimental manipulations: a) using a common set of images across both experiments, b) giving different task instructions for the two tasks, and c) extracting comparable metrics from both experimental paradigms.

Keywords: ambiguity; divergent thinking; perceptual switching.

Introduction

Every day people face situations for which new ways of seeing and thinking are necessary or at least beneficial. How are they able to arrive at these novel interpretations? Here we explore two approaches to answer this question: investigating creative problem solving (novel ways of reaching a goal) and perceptual switching (different ways of interpreting the environment). We also investigate their connection through homogeneous measurements.

Creative problem solving refers to the process of generating original and appropriate responses to reach a goal. The ability of divergent production (the generation of many possible solutions), which is instrumental to creative problem solving (see Guilford, 1967), can be assessed in numerous ways (Runco & Pritzker, 2011, p. 548). Generally, in divergent thinking tasks people are instructed to generate as many ideas as possible for visual or verbal stimuli. The number of generated distinct ideas provides a measurement of fluency or flexibility and is thought to reflect the ability to mentally restructure the stimulus.

On the other hand, consider ambiguous images such as Jastrow's bistable duck–rabbit (Jastrow, 1900, p. 295): people first perceive one of the interpretations, then after prolonged viewing the second interpretation is perceived, after which perception alternates between the two interpretations of "duck" and "rabbit" (Leopold & Logothetis, 1999; Long & Toppino, 2004). The phenomenon of switching between alternative interpretations of ambiguous images is generally known as multistable perception, or as bistable perception if only two interpretations are possible (Leopold & Logothetis, 1999). Multistability is considered to involve restructuring the interpretations of the ambiguous stimulus at higher levels of cognitive processing (Long & Toppino, 2004; Sterzer & Kleinschmidt, 2007).

Both divergent thinking and perceptual switching tasks attempt to measure the influence of perceptual and mental restructuring and are therefore thought to rely on similar processes (Schooler & Melcher, 1995). Phenomenologically, switching between different representations in divergent thinking tasks and different interpretations of an ambiguous image have been described as similar human experiences since the early 20th century by Gestalt theories (Duncker, 1963). Researchers interested in creative problem solving and multistability have been both hunting for and haunted by ambiguity for a long time. However, the commonalities between creative problem solving and perceptual switching have predominantly been observed anecdotally. Only a few studies have empirically investigated the relationship between the two phenomena.

Wiseman, Watt, Gilhooly, and Georgiou (2011) provided empirical support for the connection between perceptual switching and divergent thinking or, in general, creative ability: participants who reported that they could switch more easily to the second interpretation of the Jastrow duck–rabbit image also rated themselves as being more artistically creative and better creative problem solvers. They also found a strong correlation between self-reported ease of perceptual switching and categorical flexibility measured with a single item unusual uses task. Following up on these results, Doherty and Mair (2012) found that fluency for written responses measured with the Pattern Meanings task (Wallach & Kogan, 1965, p. 33) is positively correlated with the number of switches in perceptual multistability tasks (duck–rabbit, vase–face, Necker cube). The authors speculated that the same executive control mechanisms may be involved in perceptual switching and divergent production, therefore the relationship is worth exploring further.

The effect of ambiguous visual stimuli on divergent thinking was also investigated by Wu, Gu, and Zhang (2016) and Laukkonen and Tangen (2017). In both studies, ambiguous and non-ambiguous images were presented before a creativity task (i.e., an alternative uses task or insight problem, respectively). The results of both studies showed that participants could generate a significantly higher number of solutions in the creativity task if they saw an ambiguous figure instead of an unambiguous image. This was interpreted as evidence that ambiguous images facilitate creative ideas, possibly due to the fact that both involve resolving conflicting sensory input.

The three studies by Wiseman et al. (2011), Wu et al. (2016), and Laukkonen and Tangen (2017) show that performance in creative problem solving and perceptual switching tasks are related and can even influence each other. However, it is hard to accommodate results across tasks and studies that use different measures of divergent thinking and multistable perception.

In this study, we took images regularly used in divergent thinking and bistable perception tasks and explored whether the way they were administered affected participants' performance. Specifically, we investigated whether the images from the two paradigms led to similar temporal measures when administered in divergent thinking and perceptual switching conditions. To explore this hypothesis, we used images from a divergent thinking task, namely the Pattern Meaning task by Wallach and Kogan (1965), and compared participants' task performance with ambiguous visual stimuli such as duck–rabbit, mouse–man, donkey–seal, which are widely used in bistable research (see Wimmer, Doherty, & Collins, 2011). Finally, additional temporal measurements were extracted from the computerized divergent thinking and bistable perception tasks.

With this study, we aim to investigate to what extent task instructions and inherent stimulus characteristics influence participants' responses. Specifically, we ask whether the connection between the two phenomena can be investigated interchangeably by observing three experimental manipulations: a) using a shared set of images in both tasks, b) giving different task instructions, and c) extracting comparable metrics from both experimental paradigms. We also aim to contribute to the growing literature of empirical investigations of the relationship between divergent thinking and multistable perception.

In the first experiment, we explored whether images taken from bistable perception tasks, which are typically considered to have two interpretations, can trigger more interpretations, similarly to the images used in the divergent thinking tasks. Therefore, we presented images from divergent thinking and perceptual switching tasks to a group of participants and asked them to generate as many interpretations as possible. This is a typical administration of a divergent thinking task in creativity research, for example in Wallach and Kogan (1965).

In the second experiment, participants were presented with the same set of images in a perceptual switching task. In this case, participants were asked for an initial interpretation of one image, then shown two possible interpretations and later asked to continuously report their perception for 120 seconds. This is a setup typically employed in bistability experiments. We examined whether perceptual switching dynamics differed depending on the origin of the images.

In addition, we explored ways of directly comparing results from the two experiments. Besides the measurements which are normally used, we recorded the time participants took to generate the first answer in the divergent thinking experiment. This is similar to the concept of an initial reaction time, which is often used in the analysis of perceptual switching tasks, i.e., the time taken to report the first interpretation by button press. An additional measurement was the first phase duration, which denotes the time it took participants to name their first solution in the divergent thinking task and the time until they gave the first interpretation in the perceptual switching task. We were interested to see to what extent these two variables were similar for the same image between experiments.

Experiment 1: Divergent Thinking

Participants

Six postgraduate students aged between 25 and 48 years (mean = 37.17, SD = 8.06) participated (self-reported gender: 1 female, 3 males, 2 unspecified).

Materials and Procedure

Six different images were used, three of them taken from the Pattern Meaning task by Wallach and Kogan (1965), and three frequently used in bistable perception tasks (see Figure 1).

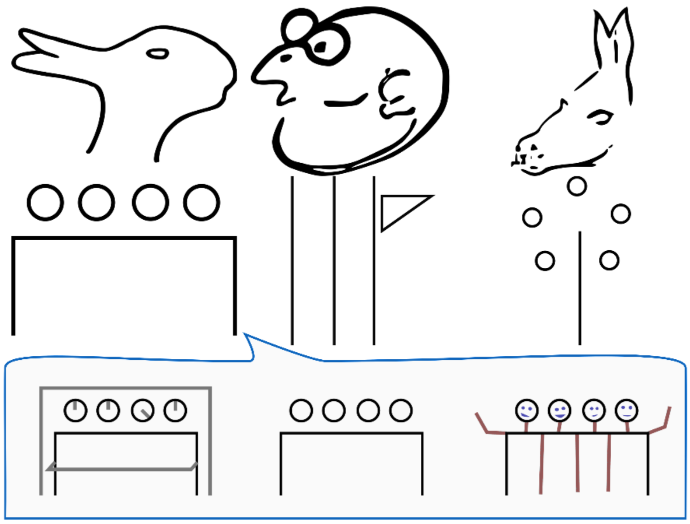

Figure 1. Images used in the two experiments; top row: duck–rabbit, man–mouse, seal–donkey; center row: oven–people, street map–flag pole, sparkling magic wand–flower; bottom row: disambiguated image for oven, ambiguous oven–people, disambiguated image for group of people.

The setup of the computerized task for each image consisted of the following three stages: "instruction," "task," and "break." During the "instruction" stage, participants were told that they should give "as many answers as [they] can" for each of the stimuli and that there were no correct or incorrect answers. Each of the six images was presented for 120 seconds, during which time participants reported their interpretations. This was followed by a self-paced "break."

For this exploratory study, fluency was chosen as one of the main measures as used in the Pattern Meaning task and other divergent thinking tasks because it can be scored objectively for any sample size. Participants' verbal responses were recorded and later transcribed along with the start and end time of each answer. Fluency was extracted as the number of responses generated during the 120 seconds of the "task," the initial reaction time (the response time t_1 from the start of the task until a participant gave the first answer) and the first phase duration (the time participants maintained their first interpretation).

Results

Fluency as the number of generated ideas is summarized in Figure 2. All participants were able to produce two or more distinct interpretations for each stimulus. The average fluency per participant across all six tasks was between 4.17 and 8.33 and the initial answer was produced between $1.67 < t_1 < 8.46$ seconds after task start. The average fluency for images from divergent thinking tasks across all participants (mean = 6.50, SD = 2.31) was very similar to the average for images from perceptual switching tasks (mean = 6.44, SD = 3.17).

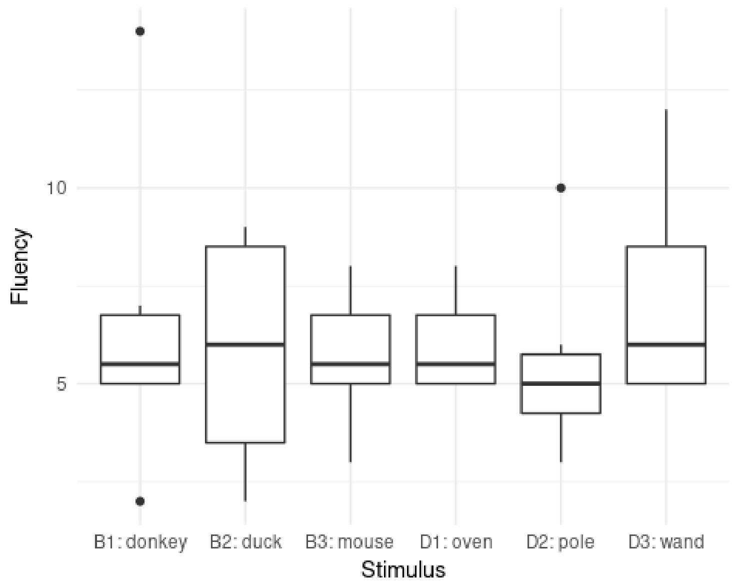

Figure 2. Number of solutions for each stimulus. The six stimuli are displayed on the x-axis and the number of solutions is displayed on the y-axis. Each of the boxes span from the first to the third quartile of the distribution of fluency; the thick line represents the median.

Experiment 2: Perceptual Switching

Participants

Six participants (five females, one male), aged between 27 and 33 years (mean = 30.17, SD = 2.32) participated.

Materials and Procedure

The same six images used in Experiment 1 were presented in a computerized perceptual switching condition (see Figure 1). A sequence of stages was administered for each image: "initial interpretation," "disambiguation," "training," "task," and "break."

Initially, participants were asked to write down their "initial interpretation" of the image. To disambiguate each line drawing from the Pattern Meaning task, the two most frequent interpretations from another study were visualized (see Figure 1). During the "disambiguation," these were used to instruct participants which interpretations of the images they should report. For example, participants who saw the image at the bottom center of Figure 1 were instructed to switch between the "oven" (bottom left) and "people" (bottom right) interpretation. In the self-paced "training," pressing one of the two defined keys on the computer keyboard showed the corresponding disambiguation on screen. During the 120 seconds of the "task," the states of the two keys were recorded continuously. The start and end times for each button press served as the basis to calculate variables such as phase duration (the length of time during which one interpretation is sustained), first phase durations and initial reaction times. At the end of each sequence of stages, participants had self-paced "breaks."

Results

The first phase durations for each stimulus are displayed in Figure 3. The two interpretations were generally well balanced (Moreno-Bote, Shpiro, Rinzel, & Rubin, 2010) for all six images, suggesting that participants perceived equally the two interpretations for each image. This shows that perceptual switching can be experienced in response to images taken from divergent thinking tasks if participants are instructed to do so.

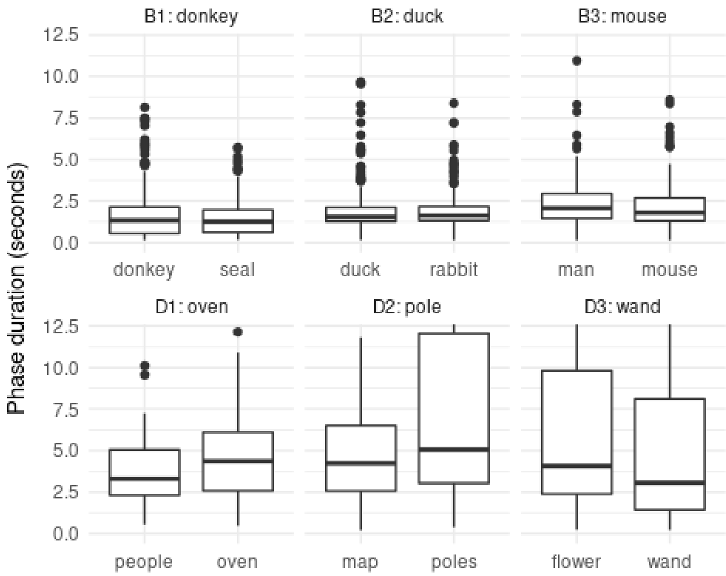

Figure 3. The average phase duration for each interpretation of each stimulus. The phase duration (in seconds) is displayed on the y-axis, while the interpretations of the stimuli are displayed on the x-axis.

In addition to the separate analysis of the two experiments, we explored a direct experimental connection between divergent thinking and perceptual switching. For example, we extracted the initial reaction time and the first phase durations for each image from both experiments.

The initial reaction times of all participants for each of the six images is shown separately for the two experiments in Figure 4. Comparing the same image across the two experiments seems to indicate that the instructions influenced the time it took participants to generate an answer. Specifically, the initial reaction time in the divergent thinking tasks was generally shorter (median = 2.98 s) than in the perceptual switching task (median = 3.44 s), even though the data collected does not provide enough evidence to suggest a significant difference. Moreover, Figure 4 provides no indication that the initial reaction times for the three images taken from the Pattern Meaning task are different from the images taken from the perceptual switching tasks. Nevertheless, Figure 4 seems to show that some images elicit a longer time until the first interpretation in both experiments (e.g., pole–street), while other images (e.g., oven–group of people) cause shorter reaction times in both experiments.

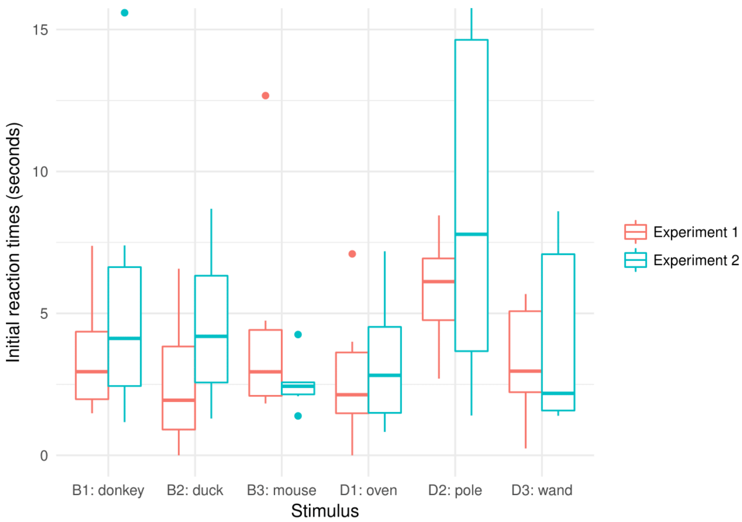

Figure 4. Distributions of the initial reaction times for each of the six images, separately for the two experiments.

Figure 5 displays the first phase duration for each image across all participants and experiments. It also seems to indicate that the first phase duration for some images is short for both experiments (e.g., donkey–seal and duck–rabbit) while participants maintain the first interpretation for a longer time for line drawings (e.g., street map–flag pole). Overall, the first phase duration for the divergent thinking task in Experiment 1 is shorter (median = 1.71 s) than for the perceptual switching task in Experiment 2 (median = 2.52 s).

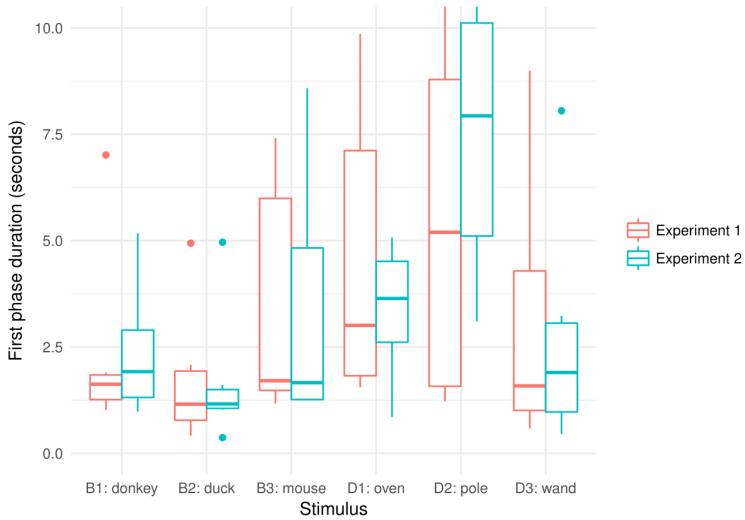

Figure 5. Distribution of the first phase duration for each of the six images, separately for the two experiments.

Discussion

The aim of the current study was to explore the connection between divergent thinking and perceptual switching. To investigate this, we collected a set of images previously used in divergent thinking or perceptual switching tasks. We then observed to what extent this combined set of images can be used in each of the original tasks. Moreover, we aimed to investigate whether participants' responses could indicate whether the original source of the image had an impact on the results. This would allow us to identify whether, except for the instructions, there are inherent characteristics that differentiate the two sources of images.

In the first experiment, images taken from divergent thinking and perceptual switching paradigms were presented to participants as typically done in divergent thinking tasks, while in the second experiment the same images were presented as typically done in perceptual switching tasks. The influence of instructions in the two tasks can be observed, for example, when we compare the initial reaction times and first phase durations for the same image from the two experiments. For both measures the results showed that instructions lead to different results based on the two tasks that participants were instructed to complete. These results indicate that instructions play a significant role in the way different images are interpreted, a claim that is supported by previous research on the influence of instructions on divergent production (Runco, Illies, & Eisenman, 2005). The role of instructions for perceptual switching needs to be addressed more thoroughly by future research.

In Experiment 1, we found that the number of solutions does not substantially differ depending on the source of the image. This suggests that images previously used in perceptual switching tasks can have more possible interpretations than usually assumed for bistable perception—at least if instructions require this.

The phase durations measured in Experiment 2 do not indicate a clear distinction between the source of the line drawings; i.e., perceptual switching dynamics cannot be used to distinguish between images taken from perceptual switching or divergent thinking tasks. This suggests that bistable perception can also occur to some extent in response to the images taken from the divergent thinking task.

The number of participants in each experiment is small and no statistical inferences can be drawn. Nevertheless, trends indicate that there are individual differences across the selected images, independently of their original source. This result supports findings from bistable research showing that perceptual switching differs across images (see van Ee, van Dam, & Brouwer, 2005). For example, in Experiment 2 the first phase duration for image D2 (street map–flag pole, see Figure 5) is longer than for other images in the same experiment, suggesting that this image is processed differently. Previous studies that examined the connection between creativity and perceptual switching overlooked the role of different types of images (Doherty & Mair, 2012; Laukkonen & Tangen, 2017; Wiseman et al., 2011; Wu et al., 2016). It is possible that the relation between perceptual switching and creativity is found only for some images. We suggest further exploration of the origin of these differences, as they might unveil common factors affecting the relationship between the two phenomena.

One challenge in designing the perceptual switching task for Experiment 2 was to select images that were previously used in divergent thinking tasks and which could be disambiguated. Unlike the disambiguation of images from bistable research which had previously been shown to work, the disambiguation of the line drawings from Wallach and Kogan's Pattern Meaning task had not been used before. We selected the two most common answers from a previously recorded data set for three of the images from the Pattern Meaning task. Subsequently we used them to disambiguate the line drawings by adding lines (for an example, see Figure 1). The disambiguations from perceptual switching tasks, on the other hand, consist of slight changes to the position and shape of key elements of the original image. The current results do not allow us to draw any conclusions about whether the interpretations we selected for the disambiguation were the easiest to switch between, or whether other interpretations would have worked better. Feedback provided by some participants suggested that they could differentiate between the two types of images based on the way they were disambiguated. Participants described this difference in terms of difficulty to actively imagine additional features for images taken from the divergent thinking task, while for the images from perceptual switching tasks this was easier.

Further differences between the two sets of images are that the images from the Pattern Meaning task are more abstract and are based only on a few geometric shapes such as circles, lines and squares. On the other hand, the images from the perceptual switching tasks can be described as more complex and organic and are supposed to depict real objects (Strüber & Stadler, 1999). Different reaction times to abstract line drawings can be explained by the greater difficulty in processing these images as compared to content-based depictions of real-world objects. This highlights the importance of the top-down effects of imagery and memory on the perception of images, as previously summarized in Scocchia, Valsecchi, and Triesch (2014).

Another limitation of the study comes from the inability to control for participants' prior exposure to the images. Bistable stimuli are well-known images that are often referenced in arts and popular culture and participants could have known some of them. Therefore, individual prior exposure to these images might have influenced the responses in both experiments. For instance, most of the participants reported knowing the duck–rabbit image beforehand. This might have biased their responses in the divergent thinking condition, particularly if they attempted to overcome the initial fixation on the two known interpretations. Previous experience with the images might also have shortened the time of the first perceptual switch in Experiment 2. Future studies should seek to eliminate the effect of stimuli familiarity, which can affect participants' responses.

Conclusion

The present study shows that inherent stimuli characteristics and instructions play an important role in interpreting ambiguous images. Participants respond to images from divergent thinking and perceptual switching tasks according to the instructions. Specifically, participants are able to provide more than two unique solutions when instructed to do so, even for images that are typically considered to have only two interpretations. Similarly, they can be instructed to switch back and forth between two given interpretations for images that are considered to have several possible interpretations. In addition, shared metrics can be extracted from both paradigms which would allow researchers a more direct comparison between the two phenomena.

Acknowledgements

We would like to thank Monika Chylińska and Susan L. Denham for the discussions and constructive feedback on improving previous versions of this article.

This work was supported by Plymouth University and CogNovo (FP7-PEOPLE-2013-ITN-604764), a project funded by the EU Marie Skłodowska Curie programme.

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