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New Routes to Human Computer Interaction

A Transdisciplinary Approach

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Abstract

This thesis bring together different disciplines – philosophy of mind, artificial intelligence, cognitive science, cybernetics and the performing arts – in a transdisciplinary investigation that raises new questions about the human mind and our relationship with computers and machines in a way that contributes to and helps elucidate the human computer interaction (HCI) debate. It chooses transdisciplinarity as the methodology best able to mobilize new ideas and generate a different approach to HCI, one that will develop fresh insights and produce critical ways of thinking about the problems of contemporary life in relation to our interaction with technologies (in the broadest sense of the term). The thesis reconciles the artificial with human nature by using transdisciplinary methods to reduce the friction between human beings and computers. It does this by revisiting early mechanical machines and automatons (from mythology and science), as well as exploring the subject in relation to elements of the performing arts. In the process, the thesis confronts the concepts of 'artificial' and 'natural' intelligence, and explores various models of mind and intelligence, as well as examining the physicality or materiality of artefacts in terms of their congruence with the paradigm of the 'embodied mind'.

The preliminary studies and literature review carried out for the research revealed that the model of the mind currently proposed by HCI as the basis for theories of how humans interact with computers is unsatisfactory, limited and very problematic, not least because it is a disembodied and representational conception of the human mind. In order to relieve HCI of this problematic issue, the thesis introduces the concept of the 'embodied mind', which brings a deeper understanding of how the mind works; its recognition that the human mind, body and the world are interrelated entities gives us a new insight into how we can improve our interactions with machines and computers. To achieve this, the research explores the conceptualization of human characteristics such as intelligence and cognition, and confirms that these concepts are subject to change, manifested in different forms, distributed, situated and contextualized. Intelligence is not interpreted as a literal entity, as it is in cognitive psychology, or as a quality that belongs to or empowers human beings alone, but inspired by the philosophy of artificial intelligence (AI), the thesis argues that it is a manifestation that ‘emerges’ when favourable conditions facilitate interactions between agents and artefacts.

Through a focused analysis and interpretation of early automatons, robots, and artificial and mechanical machines, the study explores the concept that technology is both a practice and an imaginative idea, and not just a concrete manifestation of a solution to human problems. It perceives automatons, especially ‘fraudulent’ automatons, as true archaeological discoveries, evidence of the fact that our human ambitions and ideas are not limited by the technological expressions of different eras; they represent a special repository of the desire to capitalize on and make such ideas manifest even when the technology for their materialization is not yet available. The thesis also brings ventriloquism and puppetry into the discussion, as both objects and performative practices, in order to highlight the human relationship with the material environment, as well as related aspects of human and non-human agency. This indicates that cybernetics could prove a useful framework for an understanding of elements of the relationship between the human and the artificial.

The thesis therefore tackles the problems and limitations imposed by cognitive science, computer science and psychology, currently the main disciplines concerned with improving human relationships with computers and machines, but more specifically, it offers a more historically and philosophically informed contribution to the study of HCI.

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Author’s Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

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Lists of publications related to this thesis, relevant seminars and conferences attended are documented in Appendix 1. A selection of full papers presented and published during the course of this research are also documented in the same Appendix.

Complementary information about projects, publications, lectures and conferences is also available online at: www.transtechresearch.net/marciorocha

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Introduction

This research aims to tackle the problems and limitations imposed on the study of human computer interaction (HCI) by the cognitive sciences, the main disciplines used to analyze and improve human relationships with future technologies. The preliminary studies and literature review revealed that the model of the mind HCI uses as a model of how human beings interact with computers is unsatisfactory, limited and very problematic; its investigations into how humans interact with machines and computers are conducted from a fairly narrow disciplinary perspective. These limitations have transformed HCI into a discipline that is built on incremental improvements based on trial and error, and this has affected programmers, designers and users in a number of ways.

As a designer, trained in graphic design, I became very interested in interaction design, HCI, interactive media and interface design as I witnessed the emergence of these subjects. However, my preliminary research for this thesis highlighted how the interface obeys a reductionist model of communication that deals with only one part of the intricate problem of interaction. For instance, representation involves not only what we call ‘internal’ representations of how humans anticipate and analyze problems, but also the use of language to shape the communicational or graphic elements of the graphical user interface (GUI).

An important aspect covered by this thesis is how the contemporary understanding of the human mind can be used to reframe our understanding of interaction. One aspect that has shaped HCI as a whole is the way some concepts and techniques of interaction offer a disembodied understanding of the mind and exhibit a lack of comprehension of some aspects of how the human mind works. The problem of interaction, as well as that of the concept of mind, cannot be addressed by a partial analysis, by separating out mind, body and the world, but needs to be addressed holistically. That said, however, every study of interface runs the risk of being reductionist if it fails to understand how human cognition and intelligence are affected by representation.

The graphical interface was created to unify human and computer, but as often as not it serves to separate them. Instead of solving existing problems, the interface creates new ones, and as a consequence, the computer confronts the user as a complex and often difficult machine. It is not enough to say that users today are more computer literate and are therefore able to rely on their own abilities and levels of competence rather than depending entirely on the virtues of the computer interface. It was the realization of how limited and superficial the graphical interface approach is that stimulated my interest in computation, cognition, mind and intelligence, and in the philosophical aspects of artificial intelligence (AI).

Designers are generally trained in HCI and interactive media, but there has been little inquiry into, or reflection about, the origins of these theories and techniques – or their consequences. Designers are, in general terms, trained more in ‘what to think’ than ‘how to think’: they are encouraged to apply rules and techniques without debate. Due to this attitude, they are generally regarded as having only aesthetic concerns, as specialists who simply exist to add embellishment, thus reducing their expertise to an ornamental activity. This thesis does not intend to go further into these aspects, but it is important to note that it is of real concern that designers are not trained to manifest their creativity and imagination, but instead have become part of a loop whereby they simply follow the rules imposed by an industry that has left only a tiny space in which to express a more imaginative approach, foreclosing not only the opportunity to solve real problems in terms of human interaction with computers, but also to potentially reinvent the process.

The concept of ‘mind’ is very important in the development of theories of cognition and intelligence, and it has been fundamental to a change in the theoretical fields of cognitive science, HCI and artificial intelligence. AI, for example, offers an important theoretical support for the understanding of the human mind and human and machine intelligence. It has particular qualities as a discipline that enable it to take a distinctive approach to the theory of intelligence and to offer an interesting philosophical perspective that allows us to access a more human dimension of HCI.

The obsolete idea of the computer as a metaphor for the human mind – that is, the computational approach to understanding human cognition that claims our minds work as ‘information processors’ – is no longer part of the consensus in HCI. By contrast, the concept of the ‘embodied mind’, which this thesis brings to the analysis of the subject, introduces new elements into the understanding of how the mind operates, and as a consequence, provides new insights into how human beings’ interactions with machines and computers could be improved by perceiving the human mind, body and the world as a single, interconnected entity. This discussion is conducted using early automatons, robots, artificial and mechanical machines (informed by both mythology and science) to create another perspective through which to analyse the phenomenon of intelligence.

In this way, I have developed a more amplified, relativistic and historical interpretation of what computers are, in order to try to understand more about both past and future technologies. Instead of just looking at the future of computers and machines, my interest lies more in mythologies, old machines and automatons. In simple terms, every machine that has a mechanical device or internal processor to compute information can be thought of as a ‘computer’. Mechanical machines built to compute, process data and run automated routines are therefore interpreted in this study as computers, or at least as ancestors of the modern computer. The exploration of early mechanical machines, automatons and the mechanization of thinking, for instance, reveals that technology is both a practice and an imaginative idea, and not simply the concrete manifestation of a solution for human problems This challenges the idea that technology is only created by contingencies – it also requires human aspiration and imagination to materialize and achieve it.

HCI has a relative lack of philosophical frameworks it can use to understand the many different qualities and dimensions of the subject that appear to have been lost over time – an absence that can be addressed by exploring mythology, automatons and the performing arts. As a result, HCI has become an incremental science, underpinned by cognitive psychology, a discipline that explains cognitive function in terms of information processing, using the computational model as a metaphor for cognition. To remedy this condition, the following chapters reframe a number of concepts to enable them to function as a gateway to more humanistic dimensions of the concepts (and the models) of the mind and human and artificial intelligence.

Much of the anxiety that humans have often felt about machines – their own creations – has been reflected in the machines' construction, as well as in stories, folklore and myths. Thus, placing the discussion of the mind in the context of the early automatons allows the thesis to undertake what could be characterized as a media-archaeological investigation, which suggests that the concept of mind is volatile and affected by changes over time: different epochs present substantially different versions of the concept. It also demonstrates that intelligence and cognition are distributed, situated and affected by their contextual insertion, and are not only manifested in humans, but also in non-humans in various ways.

Finally, in the last chapter, the thesis shows how ventriloquism and puppetry are performative theatrical practices that obey a cybernetic model. Such an approach not only understands that cybernetics and performance have similarities, but more importantly, it highlights the performative nature of human interaction.

In this thesis, different elements of the subject have been explored in order to put together ideas that at first glance do not appear connected. These ideas are situated across several disciplines, none of which take the pre-eminent role in this research, and most of which are frequently engaged in transdisciplinary dispute. That said, the story of this thesis is one of a study driven by the discovery of new ideas that have gradually been transformed into a combination of reflections, which possesses both practical applications and metaphysical implications.

A careful reader will see that the problem is approached from several points of view and obliquely situated between several disciplines, including philosophy of mind, cognitive science, linguistics, computer science, HCI, AI, cybernetics, and art and performance, and the citations at the beginning of each chapter are intended to be provocative, setting the scene for the ensuing discussion.

Thesis overview

Chapter One is dedicated to the problems of mind and mental models. The HCI community has debated mental models exhaustively; this chapter therefore explains different notions of the mind and the way they are connected to different generations of cognitive science. It begins by contextualizing Alan Turing’s ideas, and examining how and why they persisted for several years until they were refuted by John Searle’s Chinese room experiment. It also shows how Turing’s ideas are reflected in HCI and AI. In practical terms, this chapter discusses how the concept of mind is fundamental to an understanding of our interaction with the world, and it provides an insight into why HCI became a field that has suffered from the lack of a more enriched view of human beings in terms of their phenomenological experiences and more visceral connections with the world.

The chapter offers a panoramic view of the field in order to demonstrate the different aspects of theories of the mind, and highlights the fact that HCI emerged as a complex interdisciplinary activity, rather than a science with clear boundaries. Nevertheless, HCI was developed inside the rationalist tradition, which was dedicated to a specific mental model. HCI theory therefore oscillated between inflexible mechanistic rules determined by behaviorist cognitive psychology and philosophical reflections and theories disconnected from design practices. The mechanistic mental model is symptomatic of this problem; it is always in the background. As a consequence, computers have increased in complexity and become more challenging to use, to the extent that other disciplines have emerged to try to fill the gap between the computer and the user.

Chapter Two discusses a more contemporary interpretation of the mind: the ‘embodied mind’ and its consequences for external cognition. It develops an explanatory framework based on the concept of the embodied cognition of the human mind and the way it is connected to contemporary discussions, such as the understanding of language. Taking the embodied perspective, the chapter explores the cognitive metaphor and how it is situated in action; that is, it analyzes cognition in terms of its enactive aspects. It explains how language and metaphor have profound effects on cognitive development, and how cognition is connected to action, by viewing language as an artefact and investigating the pervasiveness of metaphor, not just in language but also in thought and action. The chapter also addresses the theoretical position of the 'extended mind'. The extended mind theory is concerned with examining the dividing line between the mind and its environment through the lens of 'active externalism'. Using the approach of extended mind theory, it unpacks the concepts of 'distributed cognition' and 'enactive perspective'.

Chapter Three discusses concepts of intelligence in the context of HCI. This chapter is dedicated to explaining certain aspects of intelligence and how this thesis conceptualizes the phenomenon. It refrains from technical jargon in order to elucidate key concepts of intelligence and embodied cognition that are necessary to later discussions. It also serves to conceptualize intelligence as a relative property. Fundamentally, it demonstrates how intelligence can be situated in, and contextualized and affected by, historical changes in many ways. The chapter therefore provides a historical backdrop for the development of the thesis and presents the context in which its argument is developed – for instance, the importance of the idea of the computer as being intelligent in its own way and the suggestion that computers can 'manifest' intelligence. The human-centric notion of intelligence and the concept of machine intelligence are also discussed and demystified.

As an introduction to aspects of the human mind, the chapter opens a discussion of the interrelationship between developing understandings of HCI and AI. It invites key questions about the location and conceptualization of intelligence, and stimulates the consideration of intelligence, not as an absolute quality, but one that is subject to historical change. It draws questions from some basic debates that inform technological approaches to the intimate involvement of humans with machines, as well as introducing the concept of cybernetics, pointing to its fundamental differences with AI, in order to create the background for the following chapters.

Chapter Four begins by laying out the theoretical dimensions of the research, and looks at how the debate can be taken a step further through the argument on external cognition. It uses artificial machines to add a new dimension to the discussion, and introduces the ‘Turk’ (an 18th-century automaton otherwise known as the ‘Mechanical Chess Player’) to support its argument for external and distributed cognition, as well as the materiality, physicality and magical dimensions of artificial life, early mechanical machines and automatons, both in mythology and science. It confronts the notions of ‘artificial’ and ‘natural’ intelligence, questions the different models of mind and intelligence developed through history, and uses the materiality of artefacts as evidence of the congruence of the embodied mind paradigm. The discussion includes the notions of human agency, non-human agency and the agency and cognitive life of objects in order to develop a more amplified understanding of human interaction with the real world, as opposed to its symbolic representation.

Chapter Five considers cybernetics and performative experience based on the theatrical acts of puppetry and ventriloquism. It amplifies the concept that was developed in Chapter Four, but this time from the perspective of cybernetics rather than artificial intelligence. Beginning from the point of view of cybernetics, this chapter takes a selected study of puppetry and ventriloquism as a model to illustrate the interactive nature of performative objects in our lives. It intends to push the limits of cognitive science in HCI by using alternative approaches to speculate how humans and machines interact in terms of environmental qualities.

Historically, puppetry and ventriloquism have been relegated to a small niche of theatrical practice, ignoring the fact that they function as the art of articulated objects, projecting, mediating and distributing human cognition and experiences. As such, they provide a location where contemporary theories of interaction can be further explored and understood. Puppetry and ventriloquism rely on a model that can be understood as a system regulated by information and feedback, and this aspect is explored here to explain the human orchestration of objects from the point of view of cognitive capacity. This model contrasts with the ‘British variant of cybernetics’, which in Pickering’s (2010) terms, distinguishes between performative and cognitive aspects, emphasizing machines that ‘act’ rather than machines that ‘think’. The materiality and physicality of these objects and their performative nature serve as conduits for understanding the world, and suggest a model that exemplifies the performative nature of human interaction with media-objects that act, express and speak themselves by being acted and spoken through. Through the work of scholars such as Pickering (2010); Pangaro (2006); Licklider (1960); Maturana (1970); Clark (1997, 1998, 1999, 2001, 2003, 2008); Chalmers (1996); Malafouris (2008); Latour (1994, 1999), among others, the final chapter facilitates, elucidates and connects subjects and disciplines that at first glance are not clearly connected.

The thesis concludes with final remarks, observations and recommendations, and points toward future directions for HCI, which enlarge on enacted, embodied models of cognition and their application in future research, education and technical developments.

Structure of the Thesis

The three first chapters, basically introduce the problem and the theoretical framework in which the thesis is situated. As a consequence of the *Transdisciplinar* approach (methodology), might be not so clear at the first glance, because every chapter explain concepts that at first does not seems to be entirely connected. To make it clear, the metaphor of *'domino effect'* here exposed, it is elucidative to illustrate that the first three chapters is mostly, about aspects of the mind paradigm: Basically, **chapter one** presents the problem, **chapter two** introduce a more contemporary alternative to understand the mind, **and chapter three** discusses different aspects of intelligence, in order to explain models of intelligence. Chapter three also connects with Chapter Five, contrasting fundamental differences between AI and Cybernetics in terms of interaction and human mind comprehension. Finally, the three first chapters (Chapter One, Two and Three), constitutes the framework to develop the last two chapters (Chapter Four and Five), in which most original contribution is elaborated.

Theoretical framework

Chapter One	Chapter Two	Chapter Three
It explains different notions of the mind and the way they are connected to different generations of cognitive science, contextualized by the work of Alan Turing and John Searle's Chinese Room experiment. It also shows how Turing's ideas are reflected in HCI and AI **(Chapter Three)**. This chapter explains how HCI became a field that has suffered from the lack of a more enriched view of human beings in terms of their phenomenological experiences and lack of connections with the world.	Taking the embodied perspective, the chapter explores the cognitive metaphor and how cognition is situated in action in terms of its enactive aspects. It explains how cognition is connected to action, by viewing language as an artefact and investigating the pervasiveness of metaphor, not just in language but also in thought and action. Also, introduce the theoretical position of the 'extended mind', giving a more contemporary perspective of human cognition.	Fundamentally, it demonstrates how intelligence can be situated in, and contextualized and affected by, historical changes in many ways. The human-centric notion of intelligence and the concept of machine intelligence are also discussed and demystified. It invites key questions about the location and conceptualization of intelligence, and stimulates the consideration of intelligence, not as an absolute quality, but one that is subject to historical change. Introduces the concept of cybernetics **(Chapter Five),** pointing to its fundamental differences with AI, creating the background for the following chapters.

Intervention

Chapter Four

It uses artificial machines to add a new dimension to the discussion, and introduces the ‘Turk’ (an 18th-century automaton otherwise known as the ‘Mechanical Chess Player’) to support its argument for external and distributed cognition, as well as the materiality, physicality and magical dimensions of artificial life, early mechanical machines and automatons, both in mythology and science.

It uses the materiality of artefacts as evidence of the congruence of the embodied mind paradigm. The discussion includes the notions of human agency, non-human agency and the agency and cognitive life of objects in order to develop a more amplified understanding of human interaction with the real world.

Chapter Five

Amplifies the concept that was developed before **(Chapter Four)**, contrasting the perspective of cybernetics and artificial intelligence. This chapter takes a selected study of puppetry and ventriloquism as a model to illustrate the interactive nature of performative objects in our lives in ‘cybernetic’ terms. It intends to push the limits of cognitive science in HCI by using alternative approaches to speculate how humans and machines interact in terms of environmental qualities.

The materiality and physicality of these objects and their performative nature serve as conduits for understanding the world, and suggest a model that exemplifies the performative nature of human interaction with objects that act, express and speak themselves by being acted and spoken through.

Conclusion

Final Remarks

The thesis concludes with final remarks, observations and recommendations, and points toward future directions for HCI, which enlarge on enacted, embodied models of cognition and their application in future research, education and technical developments.

Chapter One

Mental Models in Human Computer Interaction:

The Unpredictable Human

> *The real enemies of our life are the ‘oughts’ and the ‘ifs’. They pull us backward into the unalterable past and forward into the unpredictable future. But real life takes place in the here and now.*
>
> Henri Nouwen

Introduction

This chapter is dedicated to understanding the idea of mental models and concepts of mind. The search for an appropriate model of the human mind is a classic problem that has been debated exhaustively within the human computer interaction (HCI) community. Mental models are basically used to predict how human beings will anticipate and respond to situations, and as such, have been applied to the development of computer systems. This process starts with software development, which is later ‘translated’ by the designer into graphical user interfaces (GUIs) or graphic representations in order to mediate the interaction between the human being and the computer. This chapter argues that the mental model is a very limited and mechanistic conceptualization of how the human mind operates; it developed out of a historical tradition of pragmatism and has, arguably, had a detrimental effect on the theory of how human beings understand and interact with computers.

This chapter suggests that much that has been developed in HCI is based on the notion of computation nurtured by cognitive science. The idea originates from the classic notion that people behave as if they were information processors, with the activity of thinking more or less equated with the process of computing, and was inherited from a generation of scholars and intellectuals who perceived mind, body and the world as completely independent of one another. They thought of the mind as a disembodied entity, thus separating human action and reasoning from its physical context. In order to explain the different notions of the mind and their connections with the different generations of cognitive science, the chapter contextualizes the ideas of computer scientist, logician and cryptologist Alan Turing, and suggests that they were not only emblematic but extremely influential; they continued to persist for several decades, especially in HCI. In practical terms, a concept of mind is fundamental to an understanding of our interactions with the world, and it is due to the hold exerted by this narrow perspective exemplified by Turing that the field of HCI has been limited by the lack of a more enriched view of human beings and the human mind, particularly in terms of their phenomenological experience and what could be considered their visceral, embodied and embedded connection with the world.

I outline here several problems associated with the mental models prevalent in interface design in HCI – particularly the computational model of the mind – in relation to their impact on representation. These problems, which represent a consistent topic in the literature, are the remains of a heritage of representational models of the mind within HCI. This heritage is discussed in the next section, which focuses upon the notion of intelligence underpinning the ideas of interaction that have been adopted as a result. The section gives a short introduction to the origins of this predominant school of thought that persists by virtue of the mental models espoused by HCI.

Historical perspectives in HCI and cognition

HCI is well known as “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (Hewett *et al.*, 1992, 1996 p. 5). The field of HCI is, traditionally, the multidisciplinary research field responsible for rendering our interactions with technology and computers more user-friendly and natural, smoothing the relationship by using methods and techniques of approximation. However, HCI originated from a tradition that has frequently emphasized the functionality of technology, and as a consequence, it displays a timid humanistic focus. Much of the knowledge within the field of HCI is based on an archaic notion of computation, deriving from cognitive science, which maintains that people behave in the same way as information processors because the process of thinking is very similar to that of computing – this idea was common among what Lakoff and Johnson (1980, 1981, 1999) term the ‘first-generation of cognitive science’.[1] Lakoff and Johnson (1999, p. 75) describe how the scientific community took up the ideas of this ‘first generation’, because “it seemed natural [to them] that the mind could be studied in terms of its cognitive functions, ignoring any ways in which those functions arise from the body and brain”. Polkinghorne agrees:

> Lakoff and Johnson distinguish two generations in the development of cognitive sciences. The first generation, which evolved during the 1950s and 1960s, was begun, like humanistic psychology, as a movement to correct psychology’s overdependence on behavioristic understanding of humans. However, it changed direction when its approach took up the newly available computer as its model of mental functioning (Gardner, 1985). The computer model fit well with the view of Anglo-American analytic philosophy that mental reasoning, like computers, functioned by logically manipulati[ng] symbols. (Polkinghorne, 2001 p. 96)

Part of this concept was predicated upon several computing ideas that were prevalent at the time, including the strong belief in the mechanical model of the mind. This model became even more entrenched with the ideas of Turing: the ‘Turing machine’ and later on the ‘Turing test’ established concepts that have made a marked contribution to both computer science and the field of artificial intelligence.

Intelligence as computation

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[1] The term ‘the first generation of cognitive science’ is based on the assumption within the field of cognitive psychology that the computational metaphor could be used as a core hypothesis in order to understand the mind (that is, the disembodied mind).

According to Boden (2006), Turing’s influence on the history of cognitive science is without parallel. He pioneered the theory of computer science and the design of digital computers, and outlined the research program of AI. In addition, the test Turing proposed, which came to be known as the Turing test, provoked a huge philosophical response, and still elicits attention today. It consisted of an experiment, whereby an operator was placed in a closed room and asked to discover whether the questions he/she sent, using a keyboard or some other form of input device, were answered by another human being or a machine in the next room. The intention was to find out if the operator could distinguish between a real person and a computer, and thus whether the notion of intelligence could be assigned to a machine.

At the same time, the test was also an intellectual stimulant. In philosophical terms, the notion of (machine) intelligence that Turing introduced with his test was a determining factor in the creation of a certain conceptualization of human intelligence. However, it was reductive when it came to explaining human cognitive capacities, which as a result, became narrowly determined by the terms used to describe mechanical computation.

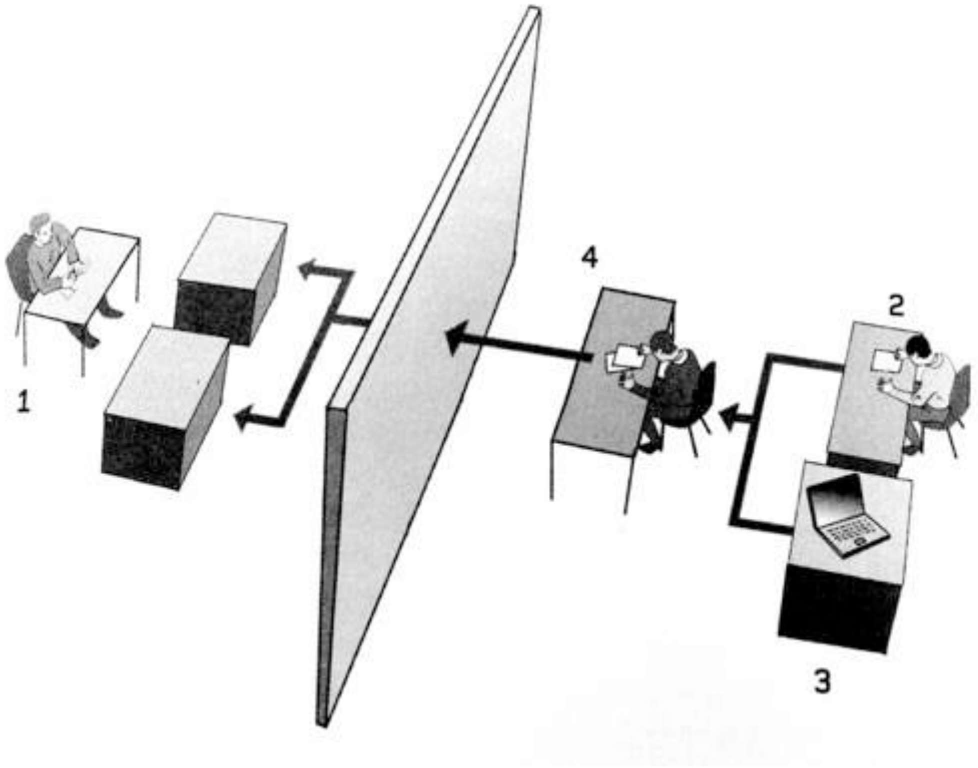

Fig. 1 The Turing test: A human questioner (1) sends questions to another room, where they are answered by a human volunteer (2) and a computer (3). The experiment controller (4) decides at random which of the two answers the questioner will receive.

Certainly, the computer is an invention with a significant history. Intellectually speaking, it has been responsible for stimulating an intense dialogue between engineers, humanists, psychologists and scientists. As an electronic logic machine, the computer created a contradictory notion that technology wields a substantial and significant influence over mankind. Part of this thinking, it is argued here, has been perpetuated from a not-so-distant past when computer scientists developed ways of testing the power of computation and hypothesized that the limits of human capacity could be overcome by means of the ingenuous notion that computing was a legitimate manifestation of a powerful new form of intelligence.[2] In this respect, Turing's ideas were undoubtedly very influential. Gradually, however, there were some advances in the thinking, and it was argued that people and computers are not similar: human thought processes are engaged with far more complex tasks than the processing of raw data.

An example of this shift in the argument is John Searle's (1980) Chinese room experiment. Searle refuted the idea that the human mental process is analogous to computing. For Searle, even if a computer simulated behavior or an intelligent dialogue, it did not necessarily mean it was able to 'think', and he maintained that humans, in turn, do more than simply manipulate symbols, they think about the symbols that are being manipulated, operating them by means of syntax and semantics – a much more dynamic and complex process than the computational model proposed by Turing could sustain. In other words, the experiment suggests that computers can process symbolic information but they cannot attach meaning to the information that has been processed. Although he conceded that humans have cognitive capacities that are capable of computing data in a similar fashion to computers, Searle's experiment systematically refutes the idea that human mental processes are similar in any other sense to computing or are simply concerned with the manipulation of symbols. For Searle, the model proposed by Turing is incomplete and fails to explain cognition.

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[2] The later development of this thesis is dedicated to elaborating the concept of 'intelligence', based on the different forms of the concept that were, historically, fundamental to the field of AI. In Chapters Three and Five the concept is amplified using the example of automatons to comprehend some aspects of human agency and non-human agency, and how material engagement with objects can be helpful in understanding some of the cognitive aspects of HCI.

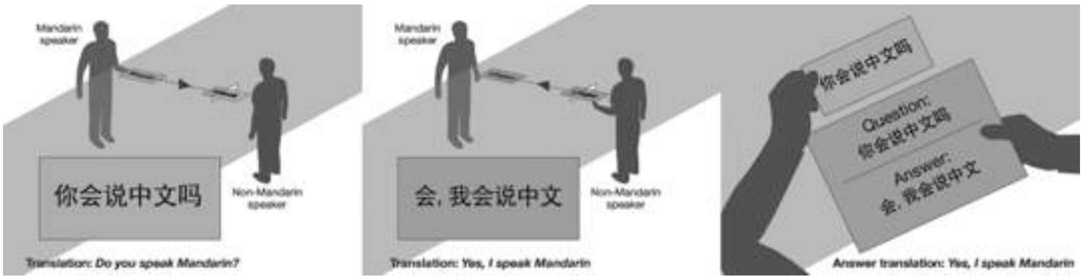

Fig. 2 The Chinese room experiment: "A native English speaker who knows no Chinese is locked in a room full of boxes of Chinese symbols (a database) together with a book of instructions for manipulating the symbols (the program). Imagine that people outside the room send in other Chinese symbols which, unknown to the person in the room, are questions in Chinese (the input). And imagine that by following the instructions in the program the man in the room is able to pass out Chinese symbols which are correct answers to the questions (the output). The program enables the person in the room to pass the Turing Test for understanding Chinese but he does not understand a word of Chinese" (Searle, 1999).

Some of the debates between these traditions can be found in the literature of theorists such as Gardner (1987), Clark (1997), Simon and Kaplan (1989), Lakoff and Johnson (1999), among others. A strand of this literature is dedicated to showing that computation is insufficient to explain this major phenomenon in a way that includes the issue of consciousness. These discussions brought substantial advances to the way scientists understand human cognition, introducing an awareness that people and computers are not similar and that human thought processes are much more complex than was hitherto believed.

Some methods were later developed to equalize user interactions with computers in an attempt to reduce the perceived friction between them (Card, Moran and Newell, 1983). These actions, classified as physical, cognitive or perceptual, served to develop techniques that provide valuable information for the study of interfaces and HCI. However, they still contained drawbacks because they did not consider how human beings could be affected by different factors such as fatigue, disability, physical limitations, habits, personality and levels of experience, as well as their social environment. Most importantly, however, cognitive psychology was still predominant among the cognitive sciences at the time and therefore the conceptualization of mind was misunderstood.[3]

The focus on usability, inherent in these approaches, also downplayed the functionality of the system, which is in turn based on a system of rules that is invariably complex and not easy to adapt. The inclusion of the use of personas and different techniques that consider the individuality of the users meant that interfaces were more specifically focused on human beings and their conditions, but they were still far from representing a definitive solution. The field then began to integrate different disciplines, but while proposing more inclusive methods, the central tendency of HCI had been essentially simplified.

The process of simplification suggests clarification; however, many of the new propositions derived from information theory, which, as a discipline, was very much involved with the way information could be quantified. It created a model that when applied to HCI was over-simplified, underestimating the user’s capacities. HCI is not only supposed to reduce errors, but also to convey information more effectively and thus create meaningful experiences. By contrast, the word ‘simplify’ shows that despite advances in the understanding of methods, human beings – paradoxically – continued to be regarded as information processors, in accordance with the theory of cognitivism. Information theory was also utilized to model systems based on human behavior, shaping systems according to human action – for example, calculating how many steps were necessary for the user to get what he/she wants, and restricting information in order to avoid overloading the human memory with data, which

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[3] One of the aspects that will be further developed is what is termed the ‘mental model’ theory as a model for an understanding of the mind. Arguably, the mental model is the heritage of the first generation of cognitive scientists, one that still persists in HCI literature and the design of the interface between people and computers. However, there have been some changes in the core of HCI that have been helpful in amplifying the understanding of interaction, with the inclusion of disciplines that are more concerned with the experience of the user, giving a new perspective that reveals that the mental model is insufficient for designing better interactions.

resulted in the system constantly warning the user to take action to prevent errors. Many of these techniques were applied by using the constraints and direct manipulation provided by the graphical user interface.

The advent of GUIs has helped to popularize the personal computer (PC), driving the integration between human being and computer, and expanding the access to computers that was once restricted to scientists, programmers and people with technical expertise. The democratization offered by the advent of the PC – and the implementation of GUIs, which transformed the computer into a popular, almost domestic appliance – stimulated the creation of a research field dedicated to understanding, studying and developing computer interfaces. However, interaction did not become less complicated and less obscure as a result. The same interface that supposedly ‘translates’ the computer, making it intelligible to ordinary users, more often divides human and machine rather than bringing them together.

Cognitive scientists have traveled the same path in the attempt to render our relationship with technology more natural and to substantially reduce the friction between humans and computers, but their efforts still seem insufficient to deal with the problem of interaction in its broader aspect. Human beings, endowed as they are with biological bodies, emotions, consciousness and free will, and subject to all the complexity of their environmental conditions, have frequently found they are unable to understand a digital repertoire that has become increasingly more complex over the years with the advent of ever-more powerful computers, not to mention cell phones and countless new electronic gadgets. The way we reflect on and produce knowledge about ourselves in the effort to understand what it means to be human is not keeping pace with the speed and dynamics of a digitized world that is in constant transformation. The conclusion is that any close analysis of either humans or computers cannot be undertaken separately and without considering the context. Any analysis that separates human beings, computers and their interactions as if they were independent of each other is bound to be reductive, incomplete and detached from any context.

Technology itself is responsible for making aspects of the computer's functions more rapid, as well as extending some human capabilities. This process of reflection about ourselves, provoked by the dissonance experienced between the nature of our self-reflection and the ecology of new digital products (part of a fast-growing technological expansion), seems to be somewhat unsynchronized. In other words, technology appears to be developing faster than our capacity to understand it, creating an even greater sense of dissonance. The use of technology is an ongoing process that both contaminates and modifies human practices; in fact, the use of technology and how it is designed is a process of mutual contamination, with deep cognitive and social implications. Human beings do not remain the same when they use a computer; they are in a process of constant cognitive transformation, stimulated by their interaction with the computer. They adapt and change through their interaction and this has an effect how we build our machines.

Indeed, there is strong evidence to indicate that the human ability to deal with technology has progressed. For example, using automation and video surveillance and control, computers have become more effective in many tasks; they perform better than human beings in a lot of different scenarios, and this is of course an interesting achievement. But it does not seem reasonable to compare human intelligence and capacities with that of computers. Conversely, what can be recognized is that intelligence can be manifested in many ways as it is not entirely independent of situation and context.[4]

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[4] I am suggesting that the notion of mind and intelligence is misunderstood in HCI; it came from a long tradition that developed from the notion of the mechanization of mind and reasoning but became more emblematic with the valorization of Turing's ideas. The arguments surrounding different ways of

A game of chess became the classic example by which scientists tested the capability of the computer, either comparing its abilities with that of human beings or simply using the experiment to understand the dynamics involved. The chess game became emblematic in computer science, indicating the degree of anthropomorphism involved in its approach, and it was also notable in the disciplines of cybernetics and AI. The use of the chess game can be tracked in the research of Shannon (1950), Levy and Newborn (1991), Hsu (2002), and Lasar (2011), among others.[5] Artificial intelligent beings, with the ability to win at chess, became a subject for literature and even mainstream films. The portrayal of the fictional computer HAL-9000, the ‘artificial agent’ in *2001: A Space Odyssey*, directed by Stanley Kubrick in 1968, was essentially a conduit for the contemplation of the evolution of monolithically inspired tools into artificial intelligence. Another example is the dystopian Los Angeles imagined by Ridley Scott in *Blade Runner* (1982), with its artificial agents known as ‘replicants’, among other cinematographic tropes.

One of the pioneers of computer chess programming was Claude Shannon (1950), with his article, ‘Programming a Computer for Playing Chess’. Even nowadays there is an entire literature dedicated to aspects of computer chess, as exemplified by Hsu (2002), Levy and Newborn (1991), Newborn (1975, 1997), and Nunn (2002), among others.

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understanding intelligence are discussed further in Chapter Three, with the notion of how the theory of intelligence within the field of AI moved on to a conception of the existence of several forms of intelligence in order to overcome its internal problems as a discipline.

[5] Wolfang von Kemplen, Charles Hooper, Konrad Zuse, Norbert Wiener, Ernst Zermelo, John von Neumann, Claude Shannon, John McCarthy, Alex Bernstein and Alan Turing, to name but a few, were also very interested in chess programming or mechanical computer chess engines.

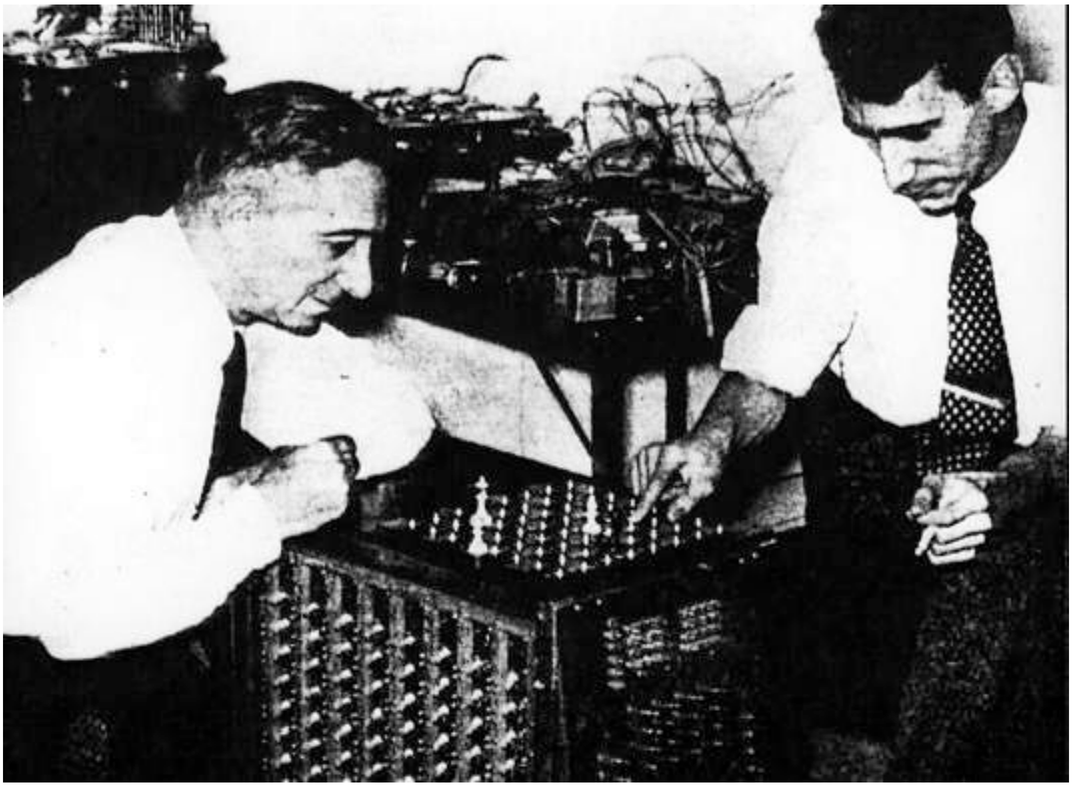

Fig. 3 Dr. Claude E. Shannon demonstrating his homemade electric chess automaton to Edward Lasker in 1949

Over the years of chess-programming development, the main conclusion that was drawn was that it is not very difficult for a computer to ‘play’ chess, even though many people would struggle to play it at a high level. There are of course levels of competence to be observed, but in general terms (and not going too deeply into the technical details), the way that computers ‘play’ chess has certain particularities. Computers are able to apply the brute force of their massive processing power, operating mathematical simulations of the most likely moves of their human opponent. Despite this, the computer is very far from playing chess in the more ‘human’ understanding of the term.

The computer will calculate and predict the movements of the pieces on the chessboard, but it will not ‘understand’ all the dynamics and complexities that are involved in a game of chess in an amplified ‘human’ sense, including predicting the actions of its opponent. Computers merely manipulate symbols, operate mathematical functions and calculate probabilities, whereas the human mind makes the game meaningful, including anticipating the frustration of losing and excitement of winning. The battle to produce computers that can simulate human intelligence is very controversial: the classic use of the game of chess to compare machine and human intelligence was supposed to reveal that computers display human-like intelligence, but conversely, such experiments made the differentiation between human and computer intelligence even more evident.

The computer’s competency is restricted to a mathematical matrix; it is limited by the mathematical representation of the board, the possibilities of the pieces in the game and their movements. This ‘expertise’ is related to computing capacity and processing power, but human beings have other, specific competencies in things that, from a human-centric point of view, are considerably more complex than a chess game, such as understanding poetry, interpreting texts, identifying nuances in images, and appreciating art and music. Predicting human actions has often proved to be a complex activity, as the following section argues, and recent history leads us to believe that there are problematic areas in which human beings can attain knowledge that is not formally computable. The conclusion is that an understanding of the biological roots behind human actions could be one way of gaining a clearer understanding of the interaction of human beings with digital technologies.

As argued earlier, the mechanization of the mind and the notion of intelligence came from the same roots. It started with the potential possibility of mechanizing reasoning through the creation of automatons and machines that could manipulate data mechanically in a binary fashion and thus simulate one aspect of human cognitive behavior, which was subsequently considered to represent ‘intelligence’. The understanding that reasoning could be reached by means of computation (manipulating information in a symbolic fashion) and processing information helped to construct the notion of (human-centric) artificial intelligence, an inheritance of a mechanistic rationalist tradition that was reinforced by later ideas developed within that tradition, particularly those of Turing. However, it is under the ‘mental model’ theory that the disembodied conceptualization of the mind became most evident.

Mental models in interface design

The use of mental models has been very persistent in interface/interaction design. The notion of the mental model dates from a particular time in the history of HCI, and is underpinned by a specific representational and predictive model of intelligence. The following section outlines the theory, and brings the limits of this heritage into focus.

Over the course of many years, cognitive science has become an interdisciplinary area of knowledge devoted to understanding human cognitive processes and modelling the interaction between people and machines. One of the most frequently debated theories of the development of human interaction with computers holds that it is possible to predict or ‘map’ how people will use the systems and anticipate their actions. Understanding and anticipating the user’s mental model has been one of the most common, if debatable, concerns of HCI and interactive design. The equation is very simple: it is believed that knowing how people think or act on a daily basis is essential to anticipating their needs and thus designing effective interactive systems. This concept is what is known as a ‘mental model’.[6]

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[6] Authors use various terms to describe this notion: mental models, conceptual models, cognitive models, mental models discourse, component models and causal models. (See Staggers, N. and A.F. Norgio (1993). ‘Mental models: concepts for human-computer interaction research’. *International Journal of Man-Machine Studies*, 38: 587-605.)

In his seminal paper, ‘The History of Mental Models’, psychologist Johnson-Laird (1980) shows that the mental model has its roots firmly in the rationalist tradition. He contends that several 19th-century thinkers anticipated the theory; the approach exemplified by the mental model was characteristic of scientific thinking at the time, especially within physics. Johnson-Laird illustrates this point by citing the physicist, Lord Kelvin, who stressed the importance of constructing mechanical models of scientific theories in order to understand abstract concepts. In his 1884 Baltimore lectures, Kelvin asserted:

> I never satisfy myself until I can make a mechanical model of a thing. If I can make a mechanical model I can understand it. As long as I cannot make a mechanical model all the way through I cannot understand; and that is why I cannot get the electro-magnetic theory. (Kelvin cited in Smith and Wise, 1989, p. 464)

Johnson-Laird explains that Kelvin never accepted Maxwell’s equations proving electro-magnetism because he could not construct a mechanical model of the theory, and continues: “Ironically, Maxwell did have a mechanical model in mind in developing his theory” (Johnson-Laird, 1979, p. 180).

Pierre Maurice Marie Duhem argue:

> The use of similar mechanical models, recalling the essential features of the theory they are trying to present through certain more or less crude analogies, is constant in English treatises on physics. Some, like Maxwell’s electrical treatise, make only moderate use of them. Others, on the contrary, make a continuous appeal to these mechanical representations. (Duhen, 1996, pp. 54)

For these authors, outlining a theory using mechanical models – “ropes running over pulleys,

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wrapping around drums running across beads and carrying weights, tubes pumping water, cog-wheels” – sometimes does not help. They also highlight the cultural differences between the English and French traditions when they say:

> It is far from the case that these models help French readers to understand a theory, on the contrary, in many cases the French must make a serious effort to understand the abstract theory, which the model claims to embody it in its pure form. (Duhen, 1996, pp. 54)

Dreyfus draws the same parallel with regard to reasoning and calculation:

> Since the Greeks invented logic and geometry, the idea that all reasoning might be reduced to some kind of calculation so that all arguments could be settled once and for all has fascinated most of the Western tradition’s rigorous thinkers. (Dreyfus, 1972, p. xv)

Can the world be anticipated?

A wide range of HCI theory has been developed that refers to mental models, or more specifically, to how human mental processes operate in the real world. Johnson-Laird, for example, raises some important questions about how human beings ‘anticipate’ the world:

> What is the end result of perception? What is the output of linguistic comprehension? How do we anticipate the world, and make sensible decisions about what to do? What underlies thinking and reasoning? One answer to these questions is that we rely on mental models of the world. (Johnson-Laird, 1980, p. 179)

For Johnson-Laird, perception yields a mental model, linguistic comprehension yields a mental model, and thinking and reasoning represent the ‘internal’ manipulation of mental models. The idea that an organism may make use of an internal model of the world is not new; it predates the advent of digital computers, with Kenneth Craik’s *The Nature of Explanation*:

> If the organism carries a ‘small-scale model’ of external reality and of its possible actions within its head, it is able to try out various alternatives, conclude which is the best of them, react to future situations before they arise, utilize the knowledge of past events in dealing with the present and the future, and in every way to react in a much fuller, safer, and more competent manner to the emergencies which face it. (Craik, 1943, p. 61)

A mental model is a widely accepted concept in the HCI literature; it can be described as an explanation of the thought processes engaged in interpreting how things work in the real world (Johnson-Laird, 1983). In this sense, it is a representation of this world, the relationships between its various parts and a person’s intuitive perception about their own actions and their consequences. Mental models thus help shape human behavior and define the human approach to solving problems and carrying out tasks. Computer systems are, to a great extent, based on the results of these models.

But how is it possible to anticipate what will happen or to map people’s thinking? How can we make decisions based on these conclusions? Mental models have traditionally provided the answers to these questions. However, despite advances in the theory, it is still possible to perceive how difficult some users continue to find using the computer with any reasonable consistency, which suggests it is not enough to rely on mental models in the development of effective computer interfaces. Fodor (2001) claims that cognitive scientists do not really understand how the human mind works, even though HCI has traditionally relied on mental models to explain how humans try to anticipate the world.

The main problems with the mental model theory

The applicability of mental models in practical terms is debatable. Observing the advances that users have made in their interaction with computers tends to hide the difficulty some find with computer interfaces that are all based on the representational mental model. To some extent, mental models have proved insufficient; it is not possible to rely entirely on mental models for the development of systems. There is also a design problem: mental models in HCI remain controversial and difficult to translate in design terms because they are too vague and not prescriptive enough, but work more as abstractions.

For Rogers (2012, p. 83), "[m]any of the theoretically based concepts promoted in HCI, that were drawn from a variety of disciplines, have largely fallen by the wayside, while a few have become common parlance. For example, the notions of affordances and context are those that have stuck and become mainstream while concepts such as mental models and cognitive dimensions, while popular to begin with, are no longer fashionable". He continues:

> Despite having much currency, the latter proved a step too far for designers (and others) to become sufficiently versed in to be able to talk about design issues with each other using such terms as viscosity … It seems akin to ask[ing] people to learn a new language late on in life, such as Esperanto, which if everyone learnt it, it would be great, greatly increasing our capacity for articulating design concerns. We would have shared references and would not spend countless hours aligning what we each mean by our nuanced meanings of common terms such as representation, platform and process. (Rogers, 2012, p. 83)

Understanding how the model works, how it can be translated into design terminology or technics, is controversial. The dissonance created by the different models that are used to understand how a computer works has resulted in techniques that impose restrictions on the user's interaction with computers and on how designers and programmers articulate those interactions.

HCI is a very complex discipline with a very complex vocabulary and suite of concepts (Goms,[7] GUI, cognitive dimensions, affordance, mental models, and so on). Every new piece of research in the field not only seems to implement new techniques, but also concoct new terms to explain the new concepts it introduces or to reassess the old ones. As a consequence, there is a huge dissonance between designers, programmers and computer scientists, which clearly affects how people understand computers.

Of course, the lack of a consistent theory explaining how the mind operates did not prevent the scientific community from further developing the interaction between humans and computers and trying to finesse it. This is the point that HCI communities choose to start from. However, the first step in developing better forms of interaction should be the recognition that the prevailing model is insufficient, leading to an attempt to create alternative methods. Cognitive scientists cannot just assume that there is one way to interact with computers and turn a blind eye to other models or ways of understanding the mind that could prove more fruitful. HCI cannot base itself solely upon ideas from what Johnson-Laird, Girotto and Legrenzi (1998) call a "radically incomplete" theory of how the human mind operates:

> We should also add that the theory (mental models) accounts for the informality of arguments in science and daily life, whereas logic is notoriously of little help in analyzing them. If people base such arguments on mental models, then there is no reason to suppose that

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[7] One of the most utilized techniques for the design of interactive systems, called GOMS (Goals, Operators, Methods and Selection rules) was popularized by Stuart Card, Thomas Moran and Allen Newell in their book, *The Psychology of Human Computer Interaction* (1993). It is not only based on an information-processor model of the mind, but is also widely used in the engineering-oriented usability community.

> they will lay them out like the steps of a formal proof. The theory of mental models, however, is not a paragon. It is radically incomplete; and it is likely to have problems and deficiencies. (Johnson-Laird, Girotto and Legrenzi, 1998, p.12)

Mental models are resilient

Despite all the criticism, mental models are still surprisingly popular in HCI, as Imaz and Benyon observe:

> Mental models are popular in cognitive psychology and HCI where they are often synonymous with trying to understand how people think some device or system works. Psychologists try to understand people's mental models of electricity, a central heating system, or an automated teller machine. People might use mental models to solve problems when there is a breakdown (for example, your car does not start), work out the mapping between actions and events, or fill in the details of some description. (Imaz and Benyon, 2006, p. 21)

As Suchman points out, computational theory is very persistent; most cognitive scientists understand cognition literally in terms of computational accounts:

> The agreement among all participants in cognitive sciences and its affiliated disciplines, however, is that cognition is not just potentially *like* computation; it literally *is* computational. There is no reason, in principle, why there should not be a computational account of mind, therefore, and there is no priori reason to draw a principled boundary between people, taken as information-processors or symbol manipulators or … certain computer machines. (Suchman, 2007, p. 37)

The mental model is still very persistent in HCI, and the main manifestation of this model is in the literature. Looking at HCI through the lens of the mental model theory, it can be seen that the fact that it was created from, and continues to follow, a more rationalistic tradition (and the modeling approach this proposes) is no more than an attempt to ‘reverse-engineer’ the human mind to anticipate events.

According to its theorists, a mental model is useful in the quest to understand how to shape human behavior and define the human approach to solving problems and carrying out tasks; therefore, computer systems are substantially based on these models. But can we really anticipate the world? How predictable are humans? Such a way of thinking is like the Newtonian idea, long surpassed, that was predominant in physics until the early 20th century, in which, by understanding initial states and conditions, the world could be apprehended because it was believed to be completely predictable and deterministic. Winograd and Flores provide a full historical account of the rationalistic tradition and its impact on computer development:

> Current thinking about computers and their impact on society has been shaped by a rationalistic tradition that needs to be re-examined and challenged as a source of understanding. As a first step we will characterize the tradition of rationalism has been the mainspring of western science and technology, and has demonstrated its effectiveness most clearly in the ‘hard sciences’ – those that explain the operation of deterministic mechanisms whose principles can be captured in formal systems. The tradition finds its highest expression in mathematics and logic, and has greatly influenced the development of linguistic and cognitive psychology. (Winograd and Flores, 1986, 1987, p. 14)

There is not any significant reason that explains why mental models became central to the development of HCI, unless it was imposed by cognitive psychology or its adoption was simply arbitrary. In terms of interaction, their impact has been ineffectual: most systems restrict user actions and prevent the user from making mistakes, imposing limits and restrictions established by the strategies embedded in the GUI, and this suggests that mental models are either poorly mapped, misunderstood or seriously defective, as people still have problems in understanding computers.

Mental models are also discussed in the literature. Norman (1983) describes them as contradictory, incomplete, superstitious, erroneous, unstable and variable in time:

> 1. Mental models are incomplete.
> 2. People's abilities to "run" their models are severely limited.
> 3. Mental models are unstable: People forget the details of the system they are using, especially when those details (or the whole system) have not been used for some period.
> 4. Mental models do not have firm boundaries: similar devices and operations get confused with one another.
> 5. Mental models are "unscientific": People maintain "superstitious" behaviour patterns even when they know they are unneeded because they cost little in physical effort and save mental effort.
> 6. Mental models are parsimonious. Often people do extra physical operations rather than the mental planning that would allow them to avoid those actions.
>
> (Norman 1983, p. 8)

The use of mental models in HCI strongly indicates how this method is based on a computational-representational notion of the mind.

Theorists such as Nöe (2009, p. 169) understand that "[t]he limitation of the computer model of the mind is the limitation of any approach to mind that [is] restrict[ed] [to] the internal states of individuals". In other words, if we attempt to understand the human mind using only the computer model of the mind as a guide, it will prove insufficient as it only concerns individuals' 'internal states', and therefore its parameters are set according to a historically disembodied and disembedded perspective of the mind.

From mental models to embodied models

Do digital products need better design methods? This question was raised by Alan Cooper (2007, p. 36), author of one of the most popular books in HCI, in which he describes the process of creating digital products today. Cooper argues that we are experiencing an incredible transformation from the age of industrial mechanical artefacts to the age of digital information objects. In his view, this represents a clear opposition between mechanical-age and information-age representative models. He proposes that new technology demands new representations.

Cooper's views of how computer interaction should be designed indicates that he believes that the limited and dualistic mindset identified earlier has persisted in HCI, particularly with regard to how models of the mind are idealized. Cooper (2007) states that HCI applies three different models to the understanding of how the computer interface is designed for the user: the 'implementation model', the 'represented model' and the 'mental model'. Each reflects a particular standpoint concerning the design of computer interfaces – software design reflects the implementation of a model or system of models, which in turn reflects the technology. The mental model reflects the user's view and the represented model or 'designer's model', the designer's view. However, as Cooper shows, if all these models are properly equalized, it creates what he calls a ‘cognitive dissonance’.[8]

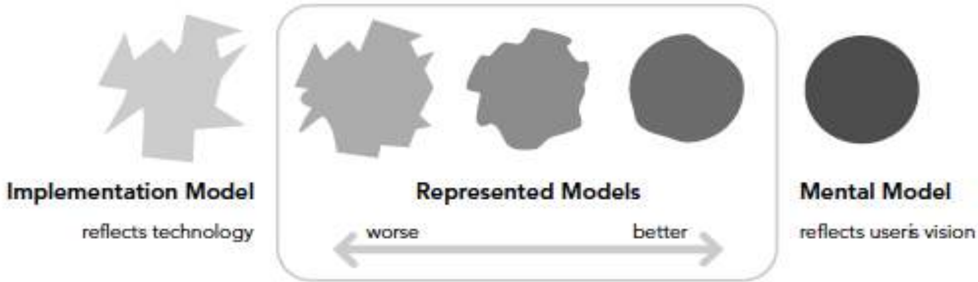

Fig. 4 HCI models and their cognitive dissonance (Cooper, 2007)

Cooper (2007) explains that the way engineers build the software is dictated by business and technical constraints, and the model for how the software actually works is called the implementation model. This model, however, contrasts with the way that users perceive how they need to perform their tasks; they formulate a different model reflecting how they interact with the software and based on the their assumptions of how the software and the computer might work – this is called the mental model. On the other hand, the way designers choose to represent the working of the program to the user is called the represented model.

Is the logic behind Cooper’s reflections inconsistent and reductionist? It probably is. Every person will experiment and display a completely different and individual behavior in the way they operate and act in the world. We can discover some behavioral patterns, especially when

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[8] Cognitive dissonance was developed by Leon Festinger on his seminal work (1957) and is a relatively straightforward social psychology theory that has wide acceptance in several disciplines, including those concerned with communication, and has been adopted by the HCI community. It is described as *“the state of having inconsistent thoughts, beliefs, or attitudes, especially as relating to decisions and attitude change”*, demonstrating the inadequacy of stimulus-response conditioning accounts of human behavior (To know more see: Festinger, L. (1957). *A Theory of Cognitive Dissonance.* Stanford, CA: Stanford University Press).

we explore the role that cultural determinants play in shaping how people behave in the different situations they encounter in their lives, but these are not linear. Even from the point of view of a single individual, that person will make countless contradictory decisions during his/her lifetime as we all are subject to cognitive and biological changes. We live in a dynamic world that is constantly transforming itself, so it is reasonable enough to assume that human cognition is also constantly changing in order to follow the perceptible changes in the world.

When reflecting on how people live and understand the world they live in, it is reasonable enough to assume that their individual abilities are not only situated in and sensitive to context, but are also related to their individual knowledge and different cognitive competences. For example, an astronomer will look at the night sky and see patterns and recognize constellations, whereas another person may only experience it as a mass of stars; a doctor will see the human body in a completely different way to the patient; and a mechanical engineer will display a mental model of the functioning and mechanism of a car that will not necessarily be shared by the majority of ordinary drivers.

Even inside the computer science community, it is possible to perceive that programmers' thought processes are not influenced by a single model but are permeated by an 'epistemological pluralism', as Turkle and Papert (1992, p. 3) put it. These authors develop the central thesis that "equal access to even the most basic elements of computation requires an epistemological pluralism, accepting the validity of multiple ways of knowing and thinking". For them, "computers provide a context for the development of concrete thinking. When we look at particular cases of individuals programming computers, we see a concrete and personal approach to material that runs into conflict with established ways of doing within the computer culture" (*Ibid.*).[9]

So, it is reasonable enough to assume that the dissonance within HCI does not only occur between different models, but is also based on the internal dissonance created between these models and people's individual experiences (what they know, for example, and how they understand and interact with the world, their educational attainments, and the sort of lens they use to focus their perception of the world).

However, as Cooper says:

> It is much easier to design software that reflects its implementation model. From the developer's perspective, it's perfectly logical to provide a button for every function, a field for every data input, a page for every transaction step, and a dialog for every code module. But while this adequately reflects the infrastructure of engineering efforts, it does little to provide coherent mechanisms for a user to achieve his goals. In the end, what is produced alienates and confuses the user. (Cooper, 2007, p. 32)[10]

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[9] For Turkle and Papert (1992, p. 49), "[t]he practice of computing provides support for a pluralism that is denied by its social construction". They continue: "[The] computer serves as an expressive medium for personal styles." This is exemplified using different case scenarios where Lisa, a first-year Harvard student in an introductory programming course, "had to be a different person with the machine". She could no longer "resist a pressure to think in ways that were not her own" and "her growing sense of alienation did not stem from an inability to cope with programming but from her ability to handle it in a way that came into conflict with the computer culture she had entered".

[10] Cooper (2007) explains the cognitive dissonance between the implementation model, the represented model and the mental model of the user from the point of the view of the educational approach of the individual. He understands the 'nuances' of different ways of thinking, and how the individual knowledge of programmers and designers affects the final product for the users in distinctive ways. Cooper (2007, p. 34) for instance, argues: "Most of the data structures and algorithms used to represent and manipulate information in software are logic tools based on mathematical algorithms. All programmers are fluent in these algorithms, including such things as recursion, hierarchical data structures, and multithreading. The problem arises when the user interface attempts to accurately represent the concepts of recursion, hierarchical data, or multithreading. Mathematical thinking is an implementation model trap that is particularly easy for programmers to fall into. They solve programming problems by thinking mathematically, so they naturally see these mathematical models as appropriate terms for inventing user interfaces. Nothing could be further from the truth."

The common agreement seems to be that the user does not really need to know and understand how an artefact or mechanism really works in all its nuances and internal details; they will form more simplified models about the way something works when they find they do not fully understand it. A lack of technical expertise will not prevent people from driving, for example, because they do not need to understand how an engine works in order to manipulate a car.

As Cooper explains:

> We tend to form mental models that are simpler than reality; so if we create represented models that are simpler than the actual implementation model, we help the user achieve a better understanding. Pressing the brake pedal in your car, for example, may conjure a mental image of pushing a lever that rubs against the wheels to slow you down. The actual mechanism includes hydraulic cylinders, tubing, and metal pads that squeeze on a perforated disk, but we simplify all that out of our minds, creating a more effective, albeit less accurate, mental model. (Cooper, 2007, p. 30)

For Cooper, the most important goal for the designer is to try to match the represented model with the mental model of the user, understanding in detail the way the target user will calculate how to work with the system. However, this is exactly where the theory does not translate very well: Cooper believes that users tend to form mental models that are simpler than reality, and thus, by creating represented models that are simpler than the actual implementation model, the designer will help them achieve a better understanding of the machine. For Cooper, user interfaces that are consistent with users’ mental models are much superior to those that are merely reflections of the implementation model. This is partially true, as long we differentiate between what is consistent with the user’s model and what is volatile, subject to change and not completely elucidated.

The utilization of mental models implies the questionable notion that humans are predictable or that it is possible to predict human actions in the development of interactive systems. In 1985, for example, Suchman made important observations concerning the unpredictability and unintelligibility of these models, and how interaction is both situated and also circumstantial:

> The significance of actions, and their intelligibility, resides neither in what strictly is about observable behavior, nor in the prior state of mind of the actor, but in a contingently constructed relationship between observable behavior, circumstances and intent. (Suchman, 1985, p. 77)

In a nutshell, the mental model theory presents several internal inconsistencies, and for that reason, it remains debatable. Staggers and Norcio, (1993, p. 590) believe that “[n]o one, of course, knows exactly how mental models are formed. One notion is that analogies or metaphors function as tools of thought, which helps structure unfamiliar domains”

The implication of a mental model that is based on representation is that it results in a disembodied conceptualization of the human mind. However, people navigate unfamiliar domains throughout their lives using analogy or metaphor. For this reason, it is important to understand how concepts are formed and the way knowledge is represented internally, in terms of human ontology. The mental models, or the way they have been presented in HCI, imply a disembodied notion of the human mind and, moreover, are not aligned with more contemporary theories of how concepts are shaped through analogy and metaphor. It seems the HCI community understands language, not as continuous with human experience as a whole, but strictly as communication (leading to a restricted informational and formal model of computation). As the act of thinking is not purely computational, this sort of model imposes limits on our understanding of language and also on the effective use of metaphorical concepts to improve human interaction with technology.

Computational models have brought HCI development up to this point, but they do not embrace the nuances and the complexity and plurality of contingencies that can be perceived in the world. Thus, the adoption of a more complex understanding of human mental processes is necessary if HCI is to advance. Lakoff and Johnson, for instance, have argued:

> The conventional metaphorical concepts we take as structuring our everyday conceptual system are taken by the objectivist to be non-existent. Metaphors, for them, are matters of mere language; there are no such things as metaphorical concepts. (Lakoff and Johnson, 1980 p. 211)

For Lakoff and Johnson (1980), metaphor is pervasive, not merely in language but in our conceptual systems. They consider it inconceivable that any phenomenon so fundamental to our conceptual system could not be central to an account of truth and meaning. As a result, they observe that metaphor is one of the most basic of human mechanisms for understanding experience. Similarly, the philosopher Andy Clark (1997,1998) also holds a more embodied and external-environmental understanding of language and cognition, which offers a compelling alternative to traditional computationalism. Furthermore, Lakoff and Johnson (1980) hold their own perspective of metaphor and human concepts.[11] Other scholars, such as Paul Dourish (2001) and Malcolm McCullough (2004), have worked on topics that are close to Lakoff and Johnson's approach, considering the embodied mind and emphasizing how concepts are socially constructed and cognition is distributed contextually (Hutchins, 1995).

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[11] Both perspectives will be addressed in more detail in the following chapters.

Although not essentially new fields, research in this area indicates a shift towards the recognition of the plurality of new perspectives that need to be absorbed into HCI.

The different ways in which these theories are discussed are fundamentally important for the history and development of the cognitive sciences and computer science, and for the understanding of the mind and human cognition, but they neglect some important philosophical aspects, not least the notion that mind, body and world are not separate entities.

Summary

The model of intelligence that underpins the mental models in the HCI literature is mostly representational or focused on representation. The rationalist scientific tradition has been partially responsible for shaping notions of the way we think and how we perceive the world around us. Fundamentally, it is a conceptual problem, which concerns the way humans act and how they understand language and theories, and the way things operate in the world. The Turing test is symptomatic of the rationalist tradition and symbolizes the resilience of this model of intelligence and mind, which is based entirely on representation and symbolic processes. However, instead leading to the creation of machines or computers that actually support human beings in their daily activities, history shows that, mistakenly, the development of computers was comparatively anthropomorphized.

The key fragility of these representational models is their misunderstanding of how intelligence is manifested, because they imply that interaction is predictable and therefore can be reverse-engineered. However, as this chapter has emphasized, both intelligence and interaction are dependent upon the context of the user – his/her body and its environmental experience. The utilization of mental models in HCI implies the questionable notion that humans are predictable or that it is possible to predict human actions for the purposes of developing interactive systems. Chapter Two will focus upon an embodied concept of the mind, which is more aligned with contemporary discussions on the conceptualization of the mind *in action* and the experiential impact of its environment.

Chapter Two

Mind, Bodies and Machines:

Embodied Cognition and its Consequences

The body is our general medium
for having a world.

Maurice Merleau-Ponty

Introduction

The previous chapter has detailed how the theory of the ‘mechanical mind’ historically determined that a particular way of comprehending the human mind remained the dominant and most resilient conceptualization of human mental processes in the field of HCI. This was aligned with the more computational and representational theories of mind developed in the traditional cognitive sciences. The following chapter challenges this conception and develops an explanatory framework based on an understanding of the ‘embodied cognition’ of the human mind and its connection with contemporary discussions regarding human interaction with machines.

The concept of the embodied mind reinstates the idea of interaction at a completely different level, one where the features of the physical body (beyond the brain) play a significant role in human cognitive processes. This chapter gives an overview of the embodied mind and embodied cognition in order to suggest a framework for an alternative understanding of the mind, one that is applicable to HCI. It also uses the idea of embodied cognition to present an alternative conception of language and metaphor. Language is often considered to be just a matter of representation, especially when viewed through a restricted perspective that presents it as simply a mode of communication. However, the development of new interpretations of language and metaphor, and new concepts and schema linked to the idea of the embodied mind, amplify the discussion on interaction. HCI, as a field, could benefit from the introduction of these aspects of the discourse on embodied cognition: understanding the mind in a different way could transform the way we approach the interactions between humans and computers. However, this chapter also recognizes that HCI may never be entirely free of representation, and for that reason its propositions are conciliatory rather than overtly radical.

Using the embodied mind as a model in HCI implies not only a completely new interpretation of how human beings interact with computers and machines, but also challenges the most dominant views of the mind that have traditionally held sway in cognitive science: the computational and representational theories. That said, although the mechanistic mental models described in the first chapter are outmoded, they still need to be overcome before we can reach an understanding of key concepts of the human mind in relation to interaction as well as intelligence. This will be discussed in more detail in the following chapters.

Another claim this chapter puts forward is that cognition and intelligence are made manifest through interaction. Intelligence is not a property that only belongs to human beings or even computers, but it emerges from the interaction between them. It is driven by action. In this sense, intelligence and cognition are not just properties 'of' something but are emergent 'between' things, and this is why the chapter also covers such themes as the distributed, situated and enactive aspects of cognition. The view that conscious symbol manipulation is only a small part of our active intelligence has now gained a consensus within cognitive science; this chapter reflects this position, and intends to overcome the mental model ideas that still persist inside the HCI community.

What is embodied mind and embodied cognition?

As Chapter One explained, 'first-generation' cognitive science (a term coined by Lakoff and Johnson to describe the predominant understanding of cognition in the 1950s and 1960s) developed a completely disembodied model of the mind, which subsequently became pervasive in HCI. According to Lakoff and Johnson (1999, p. 75), this cognitive scientist of the first generation focused on ideas about symbolic computation, and basically accepted "without questioning, the prevailing view that reason was disembodied and literal – as in formal logic or the manipulation of a system of signs".[12] The predominant functionalism in HCI has kept the discipline from progressing. It seems it has invariably been more concerned with the practical everyday applications of computers and their successful commercial performance, and this has prevented the HCI community from understanding some of the more human aspects that could expose it to new knowledge about, and approaches toward, human reasoning and activity, helping improve our interaction with computers.

According to Lakoff and Johnson:

> It seemed natural to assume that the mind could be studied in terms of its cognitive functions, ignoring any ways in which those functions arise from the body and brain. The mind, from this 'functionalist' perspective, was seen metaphorically as a kind of abstract computer program that could be run on any appropriate hardware. A consequence of the metaphor was that the hardware – or rather 'wetware' – was seen as determining nothing at all about the nature of the program. That is, the peculiarities of the body and brain contributed nothing to the nature of human concepts and reason. This was philosophy without flesh. There was no body in this conception of mind. (Lakoff and Johnson, 1999, pp. 75-6)

There are several theories to consider and directions to take when it comes to understanding embodied cognition; similarly, there is no complete theory to explain mind and cognition. Some approaches are more radical and, as such, dismiss any sort of representational theory, while others, such as that proposed by Clark (1999), are more sympathetic to representational

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[12] Lakoff and Johnson maintain that Anglo-American philosophy fit very well with certain dominant paradigms of that era (during the 1950s and 60s): early artificial intelligence; information-processing psychology; formal logic; generative linguistics; and early cognitive anthropology, all of which played a role in first-generation cognitive science.

analyses. Clark does not completely reject the ideas of internal representation and information processing.

The conception that the human mind and therefore cognition are embodied is based on the premise that the process of thinking is not restricted to brain activity, the entire body is involved; motor activity is directly linked to thought, and consequently to understanding. The cognitive processes are thus intrinsically connected to the body:

> [A]ccording to the embodied perspective, cognition is situated in the interaction of body and world, dynamic bodily process such as motor activity can be part of reasoning processes. … Finally, embodiment assumes that cognition evolved for action, and because of this, perception and action are not separate systems, but are inextricably linked to each other and to cognition. (Hutchins, 2010, p. 428)

The concept of the embodied mind, as proposed by Varela (1991), offers an interpretation of the dimension of human experience which reinstates consciousness and human cognition as factors underlying human behaviour. This work has its origins in the phenomenological enquiries of Merleau-Ponty, updated by scientists and philosophers such as Clark (1997), Varela *et al*. (1991), Thompson and Varela (2001), Wheeler (2005), Thompson (2007) and Hutchins (2010), among others.

Clark (1997), for instance, understands that the physical body seems to determine how human beings understand the world and how they interact with it; mind and body operate in a complementary manner, accommodating us to the world. But more than that, he suggests that part of the work of cognition does not only take place in the mind but is distributed in the environment or external world. According to Clark (2003, p. 5), "[i]t is because we are so prone to think that the mental action is all, or nearly all, on the inside, that we have developed sciences and images of the mind that are, in a fundamental sense, inadequate to their self-proclaimed target".

The concepts of the embodied mind and embodied cognition have been attracting interest as alternatives to cognitivism,[13] although, according to Clark, some disciplines have systematically marginalized these factors. HCI seems to be one of these areas:

> An increasingly influential theme, in recent years, has been the role of the physical body, and of the local environment, in promoting adaptive success. No right-minded Cognitive Scientist, to be sure, ever claimed that body and world were completely irrelevant to the understanding of mind. But there was, nonetheless, an unmistakable tendency to marginalize such factors. (Clark, 2003, p. 35)

Embodied cognition is the understanding that high-level conceptual processes are an embodied experience. This idea can be tracked in the work of Calvo and Gomila (2008), Johnson (1987), Gibbs (2006), and Lakoff and Nunes (2000). A more 'cybernetic' approach can be perceived in Bateson (1972), while more phenomenologically influenced analyses of embodied cognition can be found in Dreyfus (1982), Heidegger (1962), and Varela, Thompson and Rosch (1991). An enactive perspective of embodied cognition, built on the biological and environmental concept of 'autopoiesis', can be seen in Maturana and Varela (1997), and Hutchins' (2004) writing highlights the relationship between thought and action by emphasizing embodiment and enaction. According to Hutchins, the enactive perspective illustrates that the environment is not pre-given but is, in a fundamental sense, created by the activity of the organism.

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[13] According to M.L. Anderson (2003) (writing in *Artificial Intelligence*, 149: 91-130), and as outlined in the last chapter, cognitivism is the hypothesis that the central function of the mind – that is, thinking –can be accounted for in terms of the manipulation of symbols according to explicit rules.

Although Clark (1997) is one of the scholars who agree with the position of embodied cognition, he does not take a strong stance against representation. This is because, for Clark, a more radical theory of embodied cognition involves a complete rejection of explanations that invoke internal representations; it rejects the computational explanation in psychology. Clark views such a radical position as counterproductive, stimulating conceptual competition when progress relies on cooperation. He contends that the emergence of the role of the body and the world in cognition can complement the computational theories and representational accounts, and explains that such a position possesses a theoretical distinction:

> I would like to distinguish two different ways to appeal to facts about embodiment and environmental embedding. The first, which I will call ‘simple embodiment’, treats such facts as, primarily, constraints upon a theory of inner organization and processing. The second, which I will call ‘radical embodiment’ goes much further and treats such facts as profoundly altering the subject matter and theoretical framework of cognitive science. (Clark, 1999, p. 348)

As Clark (1999) points out, there is increasing interest within the cognitive sciences in issues concerning the physical body, the local environment, and the complex interplay between neural systems and the wider world in which they function. According to Clark (1997), embodiment and situated-ness are now frequently studied in such disciplines as psychology, philosophy, neuroscience, robotics, education, cognitive anthropology, linguistics, and dynamical systems approaches to understanding behavior and thought. But what is embodied cognition and how can we better understand the role this concept plays in cognitive terms? Clark explains:

> Consider first the swimming ability of the bluefin tuna. The bluefin tuna is a swimming prodigy, but its aquatic capabilities – its ability to turn sharply, to accelerate quickly, and to reach such high speeds –

> have long puzzled biologists. Physically speaking, so it seemed, the fish should be too weak (by about a factor of seven) to achieve these feats. However, an explanation for this prodigious ability can be found in the use of embodied, environmentally embedded action by the tuna. (Clark, 1999, p. 345)

According to Clark, theorists of fluid dynamics suggest that the tuna manipulates the local environment (the water) through bodily action. It seems that the tuna finds existing currents and exploits them to gain speed, using its tail flaps to create additional vortices and pressure gradients, which are then used for rapid acceleration and turning. The bluefin tuna's prodigious swimming capacity can thus be explained by its physical system and its active exploitation of its local environment.

Dourish (2001) also points out that although computer science has been successful as an engineering discipline, it is also a philosophical enterprise in terms of the way it represents the world, and creates and manipulates models of reality, people and action. Looking at what he calls 'embodied interaction', he refers to the phenomenological tradition (based on the work of Heidegger and Wittgenstein) that emphasizes the primacy of natural practices over abstract cognition in everyday activity. However, the field of the cognitive sciences, Varela *et al*. (1999, p.149) contest, has been resistant to such a 'philosophical' non-objective approach: "Although several cognitive scientists have recently turned to these discussions for inspiration, the spontaneous philosophy of cognitive sciences continues to resist such a nonobjective orientation."

Yet, although the theory that presents human cognition as a purely representational system is still a persistent one, an increasing number of cognitive scientists do understand the limitations of their approach and its neglect of other essential dimensions of human cognition. According to Varela:

> A growing number of researchers in all areas of cognitive science have expressed dissatisfaction with the varieties of cognitive realism. This dissatisfaction derives from a deeper source than the search for alternatives to symbol processing or even mixed ‘society of mind’ theories: it is a dissatisfaction with the very notion of a representational system. This notion obscures many essential dimensions of cognition scientifically. (Varela *et al*, 1991, p. 134)

Dourish (2001) argues that computer science is based entirely on philosophy dating from the pre-1930s, which involves reducing high-level behavior to low-level, mechanical explanations, formalizing them through pure scientific rationality, thus revealing the discipline’s history as part of a positivist, reductionist tradition. Dourish (2001, p. vii) also considers that much of cognitive science is still based on the Cartesian approach that “separates mind and matter, cognition and action”. This began to change with the work of Heidegger and Wittgenstein, who articulated new positions on cognition, language and meaning, abandoning the idea of disembodied rationality and abstract reasoning. Instead, these philosophers embraced the idea of ‘situated agents’, acting and interacting with the world in their everyday experiences. Traditional HCI, however, does not seem to incorporate these new cognitive developments adequately.

An acceptance of the centrality of the body also opens up a different way of understanding human cognitive powers. According to Wilson and Foglia (2011) “[t]he body in action is a powerful constraint on how organisms conceive their niche, as this constraint allows certain interactions and experiences to have an effect on concept formation and understanding of linguistic meaning”.

Language and metaphor

One of the problems with the mental models highlighted in the first chapter is the fact that people appear to understand things in terms of figurative language and metaphorical concepts. Figurative language clearly plays a role in cognition, and philosophers, linguists and psychologists have all contributed to its understanding in cognitive science. Mental models can surely, therefore, be understood as belonging to the linguistic arena. They raise the fundamental question of how human beings understand, conceptualize and create meaning out of their surrounding environment. As mentioned earlier, Clark (1997, 1999) tries to avoid a particularly radical conceptualization of embodied cognition; rather, his goal seems to be to reconcile aspects of language that, according to some schools of thought, should be studied in terms of representational accounts, with the concept of the embodied mind.

For Heidegger, it is language that brings man and his world into conscious existence. Heidegger claimed that consciousness and perception is shaped through language; language does not merely designate or label objects, but calls a thing into being.[14] Clark, for instance, explores the role of public language. The role of public language has been understated – it is interpreted as simply an instrument of interpersonal communication. Clark (1998) believes there is more to it; he recognizes the potential role that language and text could play in transforming, reshaping and simplifying the computational tasks that confront our biological brains. Language is a tool, an external artefact that partially constitutes the computational space where our brains negotiate problems and carry out specific cognitive tasks.

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[14] To know more about the Heideggerian approach as seen in Clark’s view of language-specific claims, see Wheeler. M. (2004) *Is Language the Ultimate Artefact?* Language Sciences, 26, 693-715.

Clark’s ideas about language are partly based on the work of Lev Vygotsky, a Soviet psychologist of the 1930s, who pioneered the idea that the use of public language had profound effects on cognitive development. As Clark (1997, p. 195) explains: “The role of language is to guide and shape our own behavior; it is a tool for structuring and controlling action and not merely a medium of information transfer between agents.” According to Clark, Vygotsky discovered that the self-directed utterance of words and phrases has certain effects on our behavior, and it is precisely this view – a supra-communicative account of language – that has ultimately been rejected.

Clark’s view is interesting, especially when confronted with the ideas of mental models and representation discussed in the first chapter. As he explains in his account of the work of Carruthers (1996), we should take the evidence of our own introspection very seriously. Carruthers, for example, understands that public language is itself the medium of a special kind of thought: inner thinking is literally composed in inner speech, so by extension, he concludes that many intra-personal uses of language are less a matter of simple communication than of public thinking. Clark observes that Carruthers’ supra-communicative view of language suggests that linguistic inputs can re-program or change the high-level computational structure of the brain itself:

> Speech and text … greatly extend the problem-solving capacities of humankind. More profoundly, the practice of putting thoughts into words alters the nature of human experience. Our thoughts become determinate and public objects, apt for rational assessment and for all kinds of meta-cognitive scrutiny. (Clark, 1998, p. 35)

Wheeler (2007), under the influence of Clark’s language-specific claims, tries to reconceptualize our linguistic abilities within a more Heideggerian tradition: he argues, for example, that Clark, understands language “in many ways [as] the ultimate artefact”. Clark’s conclusion, according to Wheeler (2004, p. 693), is a view of the human brain as “essentially a pattern-completing device, while language is an external resource which is adaptively fitted to the human brain in such a way that it enables that brain to exceed its unaided (pattern-completing) cognitive capacities, in much the same way as a pair of scissors enables us to exploit our basic manipulative capacities to fulfil new ends”.

But where does language fit into the emerging picture of the embodied, ecologically efficient agent? Clark (2006) asks this question in his paper ‘Language, embodiment, and the cognitive niche’:

> Embodied agents use bodily actions and environmental interventions to make the world a better place to think in. One useful way to approach this question is to consider language itself as a cognition-enhancing animal-built structure. To take this perspective is to view language as a kind of self-constructed cognitive niche: a persistent but never stationary material scaffolding whose crucial role in promoting thought and reason remains surprisingly poorly understood. It is the very materiality of this linguistic scaffolding, I suggest, that gives it some key benefits. By materialising thought in words, we create structures that are themselves proper objects of perception, manipulation, and (further) thought. (Clark, 2006, p. 370)

Some authors such as Dennett (1991) and Clark (1997, 1998) claim that the use of language as a cognitive skill is particularly revealing in the way it extends the boundaries of the mind beyond the boundaries of the human organism. Clark (2008, p. 44) describes language as ‘the scaffolding’ of the mind:[15] this is how language fits into our emerging picture of the plastic,

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[15] According to Clark (2008), the role of structured language as a scaffolding has been explored in a variety of literatures, ranging from Vygotskyian developmental psychology to cognitive anthropology (see, for example, Berk, 1994 ; Hutchins, 1995; Donald, 2001).

environmentally exploitative, ecologically efficient agent. In his words, “language itself is a form of mind-transforming cognitive scaffolding: a persisting, though never stationary, symbolic edifice whose critical role in promoting thought and reason remains surprisingly ill understood”.

What makes Clark’s claims different (in terms of his promotion of an idea of cognition that is not completely based on representation) is his interpretation of language as an artefact, using a sort of material symbolism in which human cognitive capacities, such as computation, can also be ‘physically’ explored in a way that reveals that the boundaries between the mind and the world are more flexible than first thought. Thus, language is an artefact that augments human beings’ computation skills, but it also a sort of scaffolding for the mind.

Clark (2008) examines three distinct but interlocking benefits of the concept of this ‘linguistic scaffold’:

> [T]he simple act of labeling the world opens up a variety of new computational opportunities and supports the discovery of increasingly abstract patterns in nature. Second, encountering or recalling structured sentences supports the development of otherwise unattainable kinds of expertise. And three, linguistic structures contribute to some of the most important yet conceptually complex of all human capacities: our ability to reflect on our own thoughts and characters and our limited but genuine capacity to control and guide the shape and contents of our own thinking. (Clark, 2008, p. 44)

In a similar way, Suchman (2007, p. 77) says: “Language takes its significance from the embedding world, in other words, even while it transforms the world into something that can be thought of and talked about.”

The role of metaphor in HCI

Another aspect of language that needs to be better understood in terms of the cognitive account is the role of metaphor. Metaphor is an important resource for designers, enabling them to construct a mental connection between the user and a digital or technological product by means of a visual representation of particular objects in the real world. Metaphor, for instance, supports the user’s experience of the interface or GUI of their personal computers. However, the HCI community has misunderstood its role. Metaphor has been regarded by the Western scientific tradition as a purely linguistic construction, which has existed since Plato, and as such, it has been misinterpreted in the HCI literature. The field’s paradigm of how metaphor operates in daily life has resulted in its lack of credibility as a legitimate resource for designers.

However, cognitive linguistic scientists have revisited the notion of metaphor, elucidating their nature and highlighting their centrality to human thought and cognition. Metaphor is more than just a linguistic ornamental resource, but is cognitively important, particularly if we accept that cognition processes and language (and as consequence, metaphor) are embodied, embedded and external, and the mind is not restricted and confined in the human head but spread across the biological organism and across objects that are physical vehicles of content in the world.

Metaphors are pervasive in everyday life, not just in language but also in thought and action (Lakoff and Johnson, 1980), and they help structure our conceptual system and the everyday activities we perform, illustrating the way the human conceptual system connects with the world. This chapter develops the paradigmatic debate concerning metaphor within the cognitive linguistic field and connects it to HCI – that is, it establishes a connection between human beings' interaction with technology and their experience of the world. Metaphor is not just about language or the rhetorical embellishment of language; this view is just one limited interpretation, based on the communication model, and belongs to one particular school of thought. Metaphor is clearly far more complex.

To understand language and metaphor inside more contemporary ideas of cognition would require a complete revision of most objectivist theories inside technological arenas where the rationalist tradition has had a stabilising and dominant effect. For example, the HCI community understands metaphor and language as disembodied mental concepts. However, metaphor is an important part of the constitution of language and thought, and is therefore crucial for design perspectives as well. It is frequently used as an instrument to turn verbal communication into visual representations – that is, as graphic interfaces for digital products, as illustrated by fig. 5, below. The first image represents a graphic interface using objects that can be found in 'real life'; the second is more like an abstraction, a simplification that uses icons, symbols and visual metaphors to represent 'real' objects and concepts in an electronic version, materialized in a graphic interface.

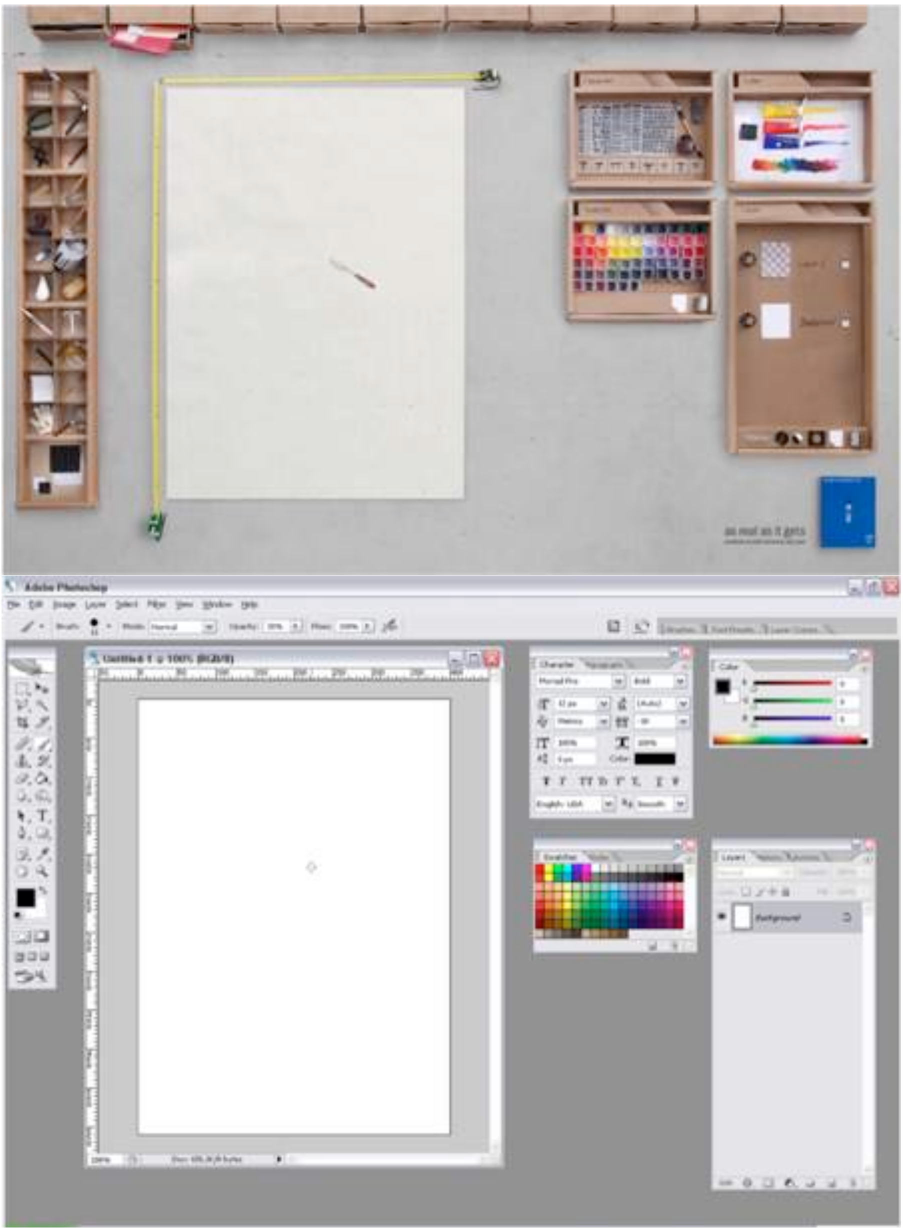

Fig. 5 Examples of the use of visual metaphors for graphical user interfaces (GUI’s)

A more contemporary, ‘embodied’ understanding of how language and metaphor operate in our daily lives could bring new elements to bear on our understanding of how human beings deal with computers, and could thus improve HCI. In the HCI literature, however, it is possible to find examples that offer profound reservations and simplistic conclusions about the efficiency of metaphors. For the HCI community, metaphors are hard to find and constrict human thinking. Metaphor, according to such an interpretation, is just figurative speech, in which one term is understood in terms of another by claiming that one is the other or by implying a comparison between the two entities. Cooper, for example, points out:

> User interfaces based on metaphors have a host of other problems as well: There aren't enough good metaphors to go around, they don't scale well, and the ability of users to recognize them is often questionable, especially across cultural boundaries. (Cooper, 2007, p. 269)

He continues: "Metaphoric interfaces are based on intuiting how things work – a risky method. Idiomatic interfaces, however, are based on learning how to accomplish things – a natural, human process" (*Ibid*., p. 270), and goes on to state:

> Metaphors also rely on associations perceived in similar ways by both the designer and the user. If the user doesn't have the same cultural background as the designer, it is easy for metaphors to fail. Even in the same or similar cultures, there can be significant misunderstandings. Does a picture of an airplane mean "check flight arrival information" or "make airline reservations?" (Cooper, 2007, p. 272)

Cooper's ideas are evidence that the mental models used by first-generation cognitive science embrace a concept of language as simply a mode of communication and metaphor as a figure of speech. For Cooper (2007, p. 267), metaphor is a "very literal approach [that could] be limiting and potentially problematic. Strict adherence to metaphors ties interfaces unnecessarily to the workings of the physical world." But embodied cognition offers a different perspective on how metaphors operate in our daily lives.

Cognitive metaphors

One important development in terms of embodied cognition is the concept of 'cognitive metaphors'. Lakoff and Johnson utilize the enactive perspective of cognition proposed by Varela, which argues that language and metaphor cannot be understood as existing only in the domain of language :

> The conventional metaphorical concepts we take as structuring our everyday conceptual system are taken by the objectivist to be non-existent. Metaphors, for them, are matters of mere language; there are no such thing as metaphorical concepts. (Lakoff and Johnson, 1980, p. 211)

Lakoff and Johnson, by contrast, perceive metaphor as pervasive, not merely in our language but also in our conceptual system, and they consider it inconceivable that any phenomenon so fundamental to our conceptual system could not be central to an account of truth and meaning. As a result, they observe that metaphor is one of the most basic of human mechanisms for understanding experience.

Lakoff and Johnson (1980) argue that language, and metaphor in particular, was not simply a phenomenon to be studied in the domain of cognition, but actively structures much of cognition traditionally thought to be isolated from metaphor. If human experience is intricately bound up with large-scale metaphors, and both experience and metaphor are shaped by the kinds of bodies we have and that mediate between us (the agent) and the world, then cognition is embodied in a way not anticipated by traditional cognitive science. For these authors, this non-literal language is not a peripheral form of expression, merely adding bells and whistles to the bustle of communication, but reflects how the source of our cognition is informed by our bodily physicality and our embodied experience as creatures who move and act in the world in order to achieve our purposes and goals.

According to Lakoff and Johnson (1980), our conceptual system thus plays a central role in defining our everyday reality. Both scholars understand that people assume that they can get along perfectly well without metaphor. However, they have found evidence proving, on the contrary, that metaphor is very pervasive in everyday life and is manifested not only through the use of the language but also in thought and action. The reason is, they claim, our ordinary conceptual system is fundamentally metaphorical in nature. Concepts are responsible for governing our thought and everyday functioning, structuring our perception of the world that surrounds us, as well as the way we relate to people. Metaphor influences the most mundane, basic details of our lives, playing a central role in defining our everyday reality. This suggests that our conceptual system is overwhelmingly metaphorical; the way human beings think, experience and do things day to day is very much a matter of metaphor.

New metaphors, like conventional ones, can have the power to define reality through a coherent network of associations that highlight some features of reality and hide others. The acceptance of the metaphor, which forces us to focus only on those aspects of our experience that it highlights, leads us to view the correspondences of the metaphor as being true. Such ‘truths’ are, of course, only true in the sense that they relate to the reality defined by the metaphor. According to Lakoff:

> Many of our activities (arguing, solving problems, budgeting time, etc.) are metaphorical in nature. The metaphorical concepts that characterize those activities structure our present reality. New metaphors have the power to create a new reality. This can begin to happen when we start to comprehend our experience in terms of a metaphor, and it becomes a deeper reality when we begin to act in terms of it. If a new metaphor enters the conceptual system that we

> base our actions on, it will alter that conceptual system and the perceptions and actions that the system gives rise to. Much of cultural change arises from the introduction of new metaphorical concepts and the loss of old ones. (Lakoff, 1980, p. 145)

Lakoff and Johnson (1980) argue that the reason why they focus their work so much on metaphor is that it has this quality of putting together reason and imagination: reason involves categorization, association and inference, and imagination involves seeing one thing in terms of another – a metaphorical thought. They call this ‘imaginative rationality’ They conclude that the categories of our everyday thought are largely metaphorical, and our everyday reasoning also involves metaphorical associations and inferences. Ordinary rationality, by its very nature, is therefore imaginative. Given that we understand poetry by means of metaphorical correspondences and inferences, Lakoff and Johnson (1980) claim that the products of the poetic imagination are, for the same reason, partially rational in nature. It is through the tool of metaphor that we partially comprehend what cannot be fully understood in rational terms, such as feelings, aesthetic experiences, or moral and spiritual practices. These endeavors of the imagination are not devoid of rationality, however; since they use metaphor, they employ an imaginative rationality:

> An experientialist approach also allows us to bridge the gap between the objectivist and subjectivist myths about impartiality and the possibility of being fair and objective. … Truth is relative to understanding, which means that there is no absolute standpoint from which to obtain absolute objective truths about the world. This does not mean that there are no truths; it means only that truth is relative to our conceptual system, which is grounded in, and constantly tested by, our experiences and those of other members of our culture in our daily interactions with other people and with our physical and cultural environments. (Lakoff, 1980, p. 193)

Language as a whole, therefore, should be understood not simply as a vehicle of communication, but also as the materialization of thought – thought that is not restricted by the idea that it exists only in our heads, but goes beyond our heads and our bodies, extending and spreading through the world. However, metaphor has not been comprehensively addressed in this way inside the HCI community, due to the fact that cognition itself has been misinterpreted. Yet cognitive metaphors have the ability to redefine reality, extending and distributing our cognitive capacities, and it seems we cannot get along without metaphor in our everyday lives.

Extending and distributing cognition

Where does the mind stop and the rest of the world begin? This was the question addressed by Chalmers and Clark (1998) in their article ‘The Extended Mind’. Although there are different views regarding this subject, they argue there are basically two positions. On the one hand, some theorists accept the demarcations of skin and skull, and claim that what is outside the body is outside the mind. On the other, there are those who are impressed by the argument that the meaning of our words is not ‘just in the head’. Chalmers and Clark (1998, p. 10), however, advocate a third position: an “active externalism that is based on the active role of the environment in driving cognitive processes”. For Clark (2011, p. xxvii), “[c]ognition leaks out into body and world”.

Fundamentally, the key idea of the extended mind theory is concerned, in large part, with the question of the point of division between the mind and the environment, which it addresses by promoting the view of ‘active externalism’. Its proponents believe that objects in the external environment are utilized by the mind in such a way that the objects could be seen as extensions of the mind itself. According to Lau and Deutsch:

> Many of our mental states such as beliefs and desires are intentional mental states, or mental states with content. *Externalism* with regard to mental content says that in order to have certain types of intentional mental states (e.g. beliefs), it is necessary to be related to the environment in the right way. *Internalism* (or *individualism*) denies this, and it affirms that having those intentional mental states depends solely on our intrinsic properties. This debate has important consequences with regard to philosophical and empirical theories of the mind, and the role of social institutions and the physical environment in constituting the mind. (Lau and Deutsch, 2014)

This is exemplified by the bluefin tuna referred to earlier, which actively creates whorls and vortices in the water to lend it propulsion. Like Clark, Hutchins (1995) also developed a study in support of the distributed cognition perspective, which states that cognition, knowledge and activity is distributed among persons, instruments and practices. This suggests that cognition is an embodied, situated and distributed activity. All these approaches recognize that body, mind and environment are locked in a harmonious interplay and are therefore connected and co-dependent. These theoretical conditions offer interesting perspectives for an analysis of how human cognition works in relation to the natural world and, further, of the kind of knowledge that could emerge as the basis for an understanding of how human beings interact with computers and other technologies.

Distributed cognition is a scientific discipline that is concerned with how cognitive activity is distributed across human minds, external cognitive artefacts and groups of people, and across space and time (Hutchins, 1995a, 1995b; Norman, 1991; Zhang, 1997a, 1997b, 1998; Zhang and Norman, 1994). In this view, people’s intelligent behavior results from interactions with external cognitive artefacts and with other people, and people's activities in concrete situations are guided, constrained and, to some extent, determined by the physical, cultural and social contexts in which they are situated (Clancey, 1997; Suchman, 1987).

Enactive perspectives

According to Clark (1999), Varela *et al.* (1991), in a discussion on the concept of the embodied mind, elucidate the active nature of perception as it organizes our coupling with the physical world, and offer powerful examples of emergent behaviour in simple systems, paying sustained attention to the notion of reciprocal (or 'circular') causation. These themes come together in the development of the idea of cognition as 'enaction':

> Enactive cognitive science, as Varela et al. define it, is a study of mind which does not depict cognition as the internal mirroring of an objective external world. Instead, it isolates the repeated sensorimotor interactions between agent and world as the basic locus of scientific and explanatory interest. (Clark, 1999, p.173)

As Hutchins also explains, enaction is the notion that our worldly experience is created through the body and is shaped by our actions:

> Embodiment and enaction are names for two approaches that strive for a new understanding of the nature of human cognition by taking seriously the fact that humans are biological creatures. Neither approach is yet well defined, but both provide some useful analytic tools for understanding real-world cognition. … Enaction is the idea that organisms create their own experience through their actions. Organisms are not passive receivers of input from the environment, but are actors in the environment such that what they experience is shaped by how they act. (Hutchins, 2010, p. 428)

These remain provocative concepts in the literature of cognitive science, to the extent that, although promising, they are not completely elucidated. However, these two assumptions provide a platform for an understanding of the body, not as a passive receiver of environmental input, but as playing an active role in the environment in which experiences are shaped by bodily actions. Such an account implies that the human learning process of cognition is not only connected to bodily doing, but is especially connected to the experience of the real world.

Despite their provocative nature, it is curious to note (in the following examples) how easy it is to incline to agree with these two assumptions drawn from embodiment. Consider the following thought experiment. When someone is shown a new object, they often want to touch and feel the object. Almost instantly, and sometimes preemptively, the person showing the object tells the person looking at it, rather humorously: “Please, look with your eyes and not your hands!” Where only looking seems insufficient, it seems necessary to pick up and feel the object. This everyday story, though simplistic, illustrates a condition rooted in human nature which suggests how interacting with objects is mediated not only by the biological body, but also by interactions that rest upon embodied perception. The perception of incompleteness is emphasized when the object is not touched. This seems like an indication that human bodies are not simply passive receivers of information but avid reactors to their experience, and include a sensorimotor system that has a predilection for acting with the environment. This might be the way in which biological bodies connect more naturally with the world around them, adapt to it and are transformed and shaped by it; it supports a cognitive perspective *embodied* in large part by the human process of thinking and learning as a result of experience. Such a perspective rejects the traditional computational view of representation, emphasizing *embodied action* as a more appropriate term.

> By using the term *embodied* we mean to highlight two points: first that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. By using the term *action* we mean to emphasize once again that sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition. (Varela *et al.*, 1991, p. 173)

Another example that illustrates the embodied nature of experience is the user's interaction with an application on a computer. At one point of the interaction (assuming this is an application that allows this relative immersion), the user forgets they are manipulating a mouse or keyboard, as they are absorbed in the content or in accomplishing the task. As Clark says :

> The accomplished writer, armed with pen and paper, usually pays no heed to the pen and paper tools while attempting to create an essay or a poem. They have become transparent equipment, tools whose use and functioning have become so deeply dovetailed to the biological system that there is a very real sense in which – while they are up and running – the problem-solving system is just the composite of the biological system and these non-biological tools. The artist's sketch pad and the blind person's cane can come to function as transparent equipment, as may certain well-used and well-integrated items of higher technology, a teenager's cell phone perhaps. Sports equipment and musical instruments often fall into the same broad category. (Clark, 2003, p. 38)

Another oft-cited example is that of a blind man with a walking stick, which assists him in the process of cognition and integrates him into his environment – as initially described by Head (1920). As Merleau-Ponty shows:

> The blind man’s stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight. (Merleau-Ponty, 1962, p. 143)

Clark also emphasizes the process by which we become able to integrate these tools, arguing that we are not born with the necessary skills, but our biological organisms are shaped to interact with these tools, and different layers of apprehension are evoked, according to the different levels of difficulty, to help integrate them with our bodies:

> Often, such integration and ease of use require training and practice. We are not born in command of the skills required. Nonetheless, some technologies may demand only skills that already suit our biological profiles, while others may demand skills that require extended training programs designed to bend the biological organism into shape. (Clark, 2003, p. 38)

Embodied and enacted models of cognition open scope for interaction to be understood not only in terms of what is being done (as in the computational approaches) but, more fundamentally, with regard to the relationships that develop between people and technologies, recognizing that body, mind and environment work in harmony, and attempting to understand them as connected and co-dependent. These conditions make embodiment and enaction interesting perspectives from which to consider how human cognition works in relation to the natural world and what kind of knowledge is necessary for an understanding of how human beings interact with digital technologies. This is particularly the case in the field of HCI, which views human beings as purely passive receivers of information and fails to recognize that cognition is linked to bodily action.

Intelligence in action

The theories described above seek to integrate embodiment, enaction and interaction in order to understand these phenomena in an interrelated fashion, and as such, represent a challenge to HCI and to the idea of interaction as a whole. This suggests that the problem is intrinsically connected to the dynamic mutability of the cognitive sciences and of HCI as a field of knowledge. In fact, interaction design has emerged as an alternative approach to HCI. This multidisciplinary and holistic approach considers a more plural point of view, not limited to human beings' relationship with computers, but connected to a much wider range of objects, products, artefacts, and to the complexity which results from this new technological ecology.

It is possible to discern, for example, a certain approximation of this interactive dimension in some technological products. Recent trends in interaction design include emotion in design; technology as experience (McCarthy and Wright, 2004); usability and pleasure in interactive products (Norman, 2004); persuasive technologies (Fogg, 2000); affective computing (Picard, 1997); affective design (Aboulafia and Bannon, 2004); autonomous agents (Tomlinson, 2005); performative design (Kuutti, Iacucci and Iacucci, 2002); and context-sensitive computing (Dourish, 2001b), among others.

As a practical example, it is possible to see some movement in the games industry, which is focused on developing products that consider the use of the body – researching and developing the use of deep sensors and skeletal tracking algorithms. These work by assigning each pixel in an image to a particular part of the body, creating a fuzzy picture of the human body, where the depth of each point is recognized using infrared sensors. The system is primarily fed a vast catalogue of data concerning captured movements that include dancing, kicking and running. Through these captured frames, body parts are identified and the system calculates the probable location of the joints and maps this information in order to build a human skeleton. The algorithm is primed to recognize the human body and to track its movements rapidly enough for them to be incorporated into the system. It is a highly innovative combination of cameras, microphones and software, which turns the user’s body into a control system, with voice-activation, video capture and facial recognition, and has great potential as an application.

Still far from being a definitive solution, this specific product takes into account the complex human biological conformation and the fact that the mind and the body seem to be equipped with different ways of conceptualizing reality – its quality lies in the way it uses this recognition to enhance the experience of learning, cognition and intuitive discovery. The rationale behind this type of product is that it considers the actions of an individual’s body as part of the process of interaction and cognition; it encourages autonomy at the same time as creating the user experience without ignoring the individual’s context.

Maturana and Varela have coined the term ‘enactivism’, which suggests that cognition depends on just such a dynamic set of relationships and context-dependent associations:

> Thus we confront the problem of understanding how our experience – the praxis of our living – is coupled to a surrounding world, which appears filled with regularities that are at every instant the result of our biological and social histories. … Indeed, the whole mechanism of generating ourselves as describers and observers tells us that our world, as the world which we bring forth in our coexistence with others, will always have precisely that mixture of regularity and mutability, that combination of solidity and shifting sand, so typical of human experience when we look at it up close. (Maturana and Varela, 1992, p. 241)

Embodiment means that the cognitive process is embedded in our bodies and enaction suggests a future potential action; both concepts are related. According to several other researchers – for example, Varela, Thompson and Rosch (1991) and Thompson (2005) – we can identify five linked ideas that constitute the notion of enaction. These are autonomy, sense-making, emergence, embodiment and experience. For now, however, this does not have any bearing on the argument in this chapter. What seems interesting from this perspective is to consider what kind of dialogue can be formalized with the new technologies. First, the computer must be recognized within a broader perspective. It is no longer a device that we use cloistered in a room at our desks or in a library; with the advance of technology, computer engineering and the growth of the processing power of these devices, coupled with miniaturization and advances in semiconductors and processors, any object can potentially be a computer if it carries within it the potential to manipulate and execute instructions. Much of the ecology of the new digital artefacts has undergone radical changes in recent years. With the advent of wireless networks, mobile technologies and touch screens, a new range of products have been created, such as laptops, netbooks, notebooks, tablets and phones. In addition to these changes, the pervasive and ubiquitous use of computing promises to increase the complexity of this new scenario, including new ways to interact with digital artefacts, using gesture, touch, movement, voice and sound, thus introducing new forms of interaction. With the new perspective of a cognitive science based on embodiment and enaction, HCI could move beyond the problems inherent to the computational model.

Exploring ‘Embodied Cognition’ into practical applications

According with Wilson (2002), Embodied cognition has recently attained high visibility. The very idea that the mind must be understood in the context of its relationship to a physical body, that interacts with the world (See chapter Four, with the Turk chess-player automaton, used as an allegory).

Embodied cognition is a very complex concept that needs to be explored in order to be transformed into practical applications, which constitutes an alternative to overcome the limitation imposed by the formal computer models based only upon symbolic representations.

According to Wilson (2002):

> "…[c]ognitive activity consisted largely of immediate, on-line interaction with the environment. Hence human cognition, rather than being centralized, abstract, and sharply distinct from peripheral input and output modules, may instead have deep roots in sensorimotor processing." (Wilson, 2002, p. 625).

Wilson (2002), discusses some aspects of embodied cognition that can be useful, in order to summarize these aspects and to be translated and more understandable into practical terms. According with Wilson (2002, p. 626):

1. Cognition is situated. Cognitive activity takes place in the context of a real-world environment, and it inherently involves perception and action.

2. Cognition is time pressured. We are “mind on the hoof ” (Clark, 1997), and cognition must be understood in terms of how it functions under the pressures of real-time interaction with the environment.

3. We off-load cognitive work onto the environment. Because of limits on our information-processing abilities (e.g., limits on attention and working memory), we exploit the environment to reduce the cognitive workload. We make the environment hold or even manipulate information for us, and we harvest that information only on a need-toknow basis.

4. The environment is part of the cognitive system. The information flow between mind and world is so dense and continuous that, for scientists studying the nature of cognitive activity, the mind alone is not a meaningful unit of analysis.

5. Cognition is for action. The function of the mind is to guide action, and cognitive mechanisms such as perception and memory must be understood in terms of their ultimate contribution to situation-appropriate behavior. 6. Off-line cognition is body based. Even when decoupled from the environment, the activity of the mind is grounded in mechanisms that evolved for interaction with the environment—that is, mechanisms of sensory processing and motor control.

Summary

Traditional HCI does not encompass the new developments of the cognitive sciences adequately, hence the call for a paradigm shift, particularly as embodied cognition could make a valuable contribution to current HCI – the dialogue between the different schools of thought would prove very beneficial for the field. The view that conscious symbol manipulation is only a small part of the explanation of how our intelligence works is increasing as the acceptance of embodied cognition grows in cognitive science and is validated by new scientific evidence. It seems clear that human cognition is very dependent on bodily capabilities, specifically in terms of sensorimotor capacities, which means it is situated, action-oriented and emergent from environmental interaction. Most of the ideas brought together here explain the new perspectives that embodied cognition bring in terms of how we can understand knowledge that has another meaning in another context (for example, how language, schema, metaphors and human cognition can be understood in symbolic fashion).

This chapter has developed this position by prospecting for new possibilities in a more contemporary understanding of human cognition, and looking at how these could be used to substantially reduce the friction between man and technology, especially in relation to HCI and interaction design. As some of the evidence indicates, the ideas of embodiment and enaction contradict the notion that the cognitive process occurs only through representation, and more than that, externalist theories suggest that the mind and cognitive processes are extended beyond the border of the individual’s body, as manifested by language and metaphors. In addition, the concepts of embodied and enacted cognition open the way to understanding interaction not only in terms of what is being done, but more fundamentally, of how this relationship is established. This argument has presented various opportunities for theoretical reflection by suggesting that the externalist theories of the philosophy of the mind can contribute a new knowledge to HCI and interaction design, expanding the theoretical reach of a subject that was originally founded upon computational theories of the mind. This is particularly the case in relation to the field of HCI, which does not recognize cognition as linked to bodily action, but views human beings as passive receivers of information.

The traditional functionalism, which dominated the early beginnings of the theories that sought to understand the relationship between human and computer, has not completely dissipated. The embodied and enactive theoretical paradigm proposed by Varela cannot be considered to have yet gained full acceptance. However, it has the merit of highlighting some internal fragilities within cognitive science, in particular its tendency to neglect dynamic phenomena, autonomy, action and contextual issues, characteristics that should also be considered by the HCI community if it wishes to develop more inclusive interactions.

Current and future research will show whether HCI can accommodate some of these aspects of cognition in a more comprehensive theory from which designers and other interested parties could benefit in some way. Above all, this theory suggests that interaction cannot continue to be constrained by a purely representational model, but is moving towards a new set of relationships that need to be considered, and this in itself represents a complete paradigm shift in the understanding of how we interact with the natural and artificial world and with the technology around us. This chapter therefore is but a part of the task of questioning, understanding and contributing to how this phenomenon can be better understood. It suggests that the understanding of language, cognitive metaphors, embodied cognition and enactive perspectives could be translated and applied to the development of best practice for HCI and interaction design.

Chapter Three

Hope and Reality in Artificial Intelligence:
The Manifestation of Intelligence

Within a generation the problem
of creating 'artificial intelligence' will be
substantially solved.

Marvin Minsky

Introduction

The concept of intelligence is not only affected by imagination, historical change and technological contingencies, but the notion itself helps determine, in turn, how we understand machines and ourselves. The history of artificial intelligence is a history of the different perspectives on the subject. There is of course the traditional technical approach, advanced by such disciplines as computer science, cognitive science, robotics and engineering; however, a more ‘humanistic’ approach, embracing art history, mythology and the study of the folklore surrounding the history of artificial machines, offers another significant framework.

By looking at the past (instead of to the future) of machines, this chapter provides an understanding of artificial intelligence that takes historical contingencies into account. It shows how different conceptualizations of intelligence accompany the history of AI, a history that encapsulates the human passion and drive to create artificial life. Based on historical, artistic and mythological evidence, the chapter raises fundamental questions concerning the location of intelligence, the way it is conceptualized, and whether it is an absolute quality or one that is subject to historical change. These questions are drawn from the debates informing the technological approach to human beings’ intimate involvement with machines. It traces the key phases of AI in order to stimulate critical and philosophical reflection on the theories informing the design of intelligent machines, addressing some of the major issues in the field.

The notion that intelligence is not only a human property but one that machines could potentially possess is an ambitious and imaginative idea that was (and still is) more advanced than the human capacity to realize it. The ambition to materialize human-centric intelligence in a machine created the false notion that intelligence could be replicated rapidly, and this led the discipline into the 'Dark Ages of AI' and a research program known colloquially as GOFAI.[16] Admitting the difficulties of creating human-centric intelligence, however, breathed new life into the field of artificial intelligence. New understandings drawn from philosophy influenced the realization that intelligence is not just a human characteristic but can be conceptualized as a relative property, one that is situated and sensitive to context. Moreover, intelligence does not *belong* to agents, whether these be human or non-human, but emerges from the organic interaction between them (that is, between human beings, machines, objects and artefacts).

The chapter develops its argument in three distinct phases. First, it uses the historical framework of AI to explain that artificial intelligence is an ambitious and imaginative idea that goes beyond the boundaries of our technological capacities to materialize it. Secondly, it goes on to argue that the symbol-manipulation notion of AI is a very limited conceptualization of intelligence, which neglects the new developments of embodied cognition and intelligence. This section also explains that the human-centric notion of intelligence is limited and we need to take into account the fact that non-human entities can develop or simulate the manifestation of intelligence through interaction with other non-human entities and objects. Lastly, it compares AI and cybernetics. It is necessary to point out the substantial differences between these disciplines in terms of their understanding of cognition: AI has traditionally been understood through a computational account of representation (until internal changes overturned the GOFAI model), while cybernetics looks at the subject more in terms of performative environmental adaptation. In this thesis, both

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[16] John Haugeland gave the name GOFAI ('Good Old-Fashioned Artificial Intelligence') to symbolic artificial intelligence in his 1985 book, *Artificial Intelligence: The Very Idea*. Symbolic AI is the collective name for all methods in artifical intelligence research that are based on high-level symbolic representations of problems. Symbolic AI was the dominant paradigm in AI research from the mid-1950s to the late-1980s.

disciplines are applied to the investigation of different models of human interaction with machines, using as examples the history of automatons and the performative artistic practices of ventriloquism and puppetry.

The conceptualization of intelligence

Artificial intelligence has a fascinating history. It was first assumed that it began with the invention of the first computer and the belief that human-like intelligence could be replicated in such machines, but this is only part of the story. One of the first references to such an undertaking that naturally comes to mind is the story of the creation of Adam recounted in the Jewish Talmud: he was one of the first automatons, made out of dust. In fact, the ‘first man’ is widely referred to throughout ancient mythology as an artificial (created) being. The word ‘Golem’ in Jewish folklore also describes an animated human-like creature, but its origins lie in the bible (Psalms 139: 16), where it means a shapeless or deformed and therefore imperfect mass. Golem is also interpreted in the Talmud as a body without a soul.

Other significant references to automatons and artificial life can be found in ancient Greek mythology. For example, Hephaestus (or Vulcan in the Roman pantheon) was not only the god of smiths but of all mechanical arts. He worked with all those substances – such as iron, gold and silver – that can be transformed by fire. Book 18 of Homer’s *Illiad* tells us that Hephaestus created two female statues out of gold – “living young damsels, filled with minds and wisdom” – who followed him wherever he went. He was also said to have made a giant brass guard called Talus, whose one vulnerable spot was his right ankle.

Fig. 6 Aphrodite visiting Hephaestus in his smithy (*Venus in Vulcan’s Workshop*. Painting by Gaetano Gandolfi, 1734-1802. Staatsgalerie, Stuttgart)

Again, there is the ancient Greek myth of Pygmalion and Galatea (retold in the Roman author Ovid’s narrative poem *Metamorphoses*). Pygmalion is a sculptor who falls in love with the statue he carves of a beautiful woman he calls Galatea. Taking offerings to the altar of Aphrodite, he asks for a bride the living likeness of his ivory girl. When he returns home, he kisses his statue and finds that its lips are warm, touches it with his hand and finds that the ivory has softened into human flesh. Aphrodite has granted his wish and brought his statue to life, and Pygmalion marries the ivory sculpture, Galatea. Such descriptions of mechanical people, animals and objects are not only found in Greek mythology, but in that of every other culture in the world. Humankind seems to possess a universal ambition to fashion mechanical creations that emulate living beings. The history of this human obsession with self-replication, therefore, did not start with the first mechanical automaton or the first computer, but began as mythologies, stories and folktales. Most importantly, it began in the imagination, as Cohen points out:

> The imagination of our time has been stirred up by an exhilarating succession of man-made robots: ultra-rapid computers, pilotless planes, artificial satellites, machines that can translate and talk, entire factories automated. They promise the fulfillment of a dream that can be traced through medieval fantasy to the legends of an immemorial past. We must therefore seek the first ancestors of modern automata in the twilight figures of a remote mythology. (Cohen, 1966, p. 15)

McCorduck shares this perception:

> Western history [is a history of the search] to mechanize thinking, beginning with the earliest mythological and literary examples, followed by philosophical tracts, mathematical formulations, automata and other kinds of devices, most importantly the digital computer, that have been proposed as ways to automate thought. (McCorduck, 2004, p. xxiii)

The fascination with representing the human image, with replicating human bodies and mental capacities, is deeply embedded in human history, and was initially driven more by imagination than the technological capacity to materialize these dreams. This is probably why some of the best predictions never came true – they were driven by passionate, ambitious and imaginative ideas, rather than by pure reason. Crevier (1993) says:

> As if driven by some invisible hand, humans have always yearned to understand what makes them think, feel, and be, and have tried to re-create that interior life artificially. Long before the vacuum tubes and

> silicon chips of the modern digital computer, long before the first analog computer, mythologies and literature recorded a timeless need to animate the inanimate, from Pygmalion’s attempt to bring to life the perfectly sculpted Galatea to Gepetto’s desire that the wooden puppet Pinocchio be a real boy. (Crevier, 1993, p. xv)

Most mechanical devices, such as the Vaucanson duck or the Turk chess-player (detailed in Chapter Four), were dedicated to performance rather than functional tasks; they were built to stimulate people’s imagination and give them pleasure. The Turk was presented as a spectacle like a magic show and was deeply performative, not in the cybernetic sense of the term, but in the way that it could *mimic* artificial intelligence at a time when the technological resources to materialize it were not available. When something is just a promise, a remote perspective on the horizon, the imagination takes over. According to Franchi and Güzeldere:

> It is important to note that while the automata in these stories are capable of intelligent behaviour, they cannot act intelligently out of their own material nature. That is, their intelligence is not manifested by virtue of their internal mechanisms. Rather, it is an additional substance, force, or otherwise causally efficacious agent that endows them with cognitive capacities and enables purposeful, intelligent action. As such, these fictional automata are not, strictly speaking, early models of what the project of artificial intelligence envisions. (Franchi and Güzeldere, 2005, p. 29)

Modern AI

The field of artificial intelligence began with great optimism. According to Rodney Brooks (1999, p. 80), “[a]rtificial intelligence started as a field whose goal was to replicate human-level intelligence in a machine. Early hopes diminished as the magnitude and difficulty of that goal was appreciated." Historically, the modern view of artificial intelligence began with Turing's highly influential conceptualization of intelligence (elaborated in the first chapter). The optimism of these beginnings created the false notion that AI researchers could replicate human intelligence, but this did not succeed, and in fact culminated in what is known as a 'degenerating' research program (GOFAI).[17] According to Dreyfus:

> Almost half a century ago computer pioneer Alan Turing suggested that a high-speed digital computer, programmed with rules and facts, might exhibit intelligent behaviour. Thus was born the field later called artificial intelligence (AI). After fifty years of effort, however, it is now clear to all but a few diehards that this attempt to produce general intelligence has failed. (Dreyfus, 1999, p. ix)

Dreyfus shows that the GOFAI program was entirely based on the Cartesian idea that human understanding consists of appropriate symbolic representations. Thus, the main goal of AI researchers was to find ways to represent and formalize common sense in a symbolic fashion in order to render it computable, but it turned out that this task was far harder than they could ever have imagined. This was because, as Dreyfus points out, the human sense of relevance is more holistic than the symbolic information-processing model of the mind could accommodate; human beings are constantly involved in ongoing activities and experiences, whereas symbolic representations are completely detached from such activity.

Dreyfus argues that the problem was not really the representation of knowledge; rather, it concerned the ability to represent the everyday common-sense cognitive background that

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[17] Dreyfus (1979) describes GOFAI as a paradigm of what philosophers of science call a 'degenerating' research program. According to Imre Lakatos, citing by Dreyfus (1979), for example, such a program is a scientific enterprise that starts out with great promise, offering a new approach that leads to impressive results in a limited domain. Almost inevitably, researchers will want to try to apply the approach more broadly, starting with problems that are in some way similar to the original one. As long as it succeeds, the research program expands and attracts followers. However, if it is no longer able to predict new phenomena or confirm new predictions, it is judged to be 'degenerating' and is abandoned.

allows us to understand what is relevant to us in the experience itself. After two decades, in the mid-1970s, AI researchers came to the fundamental conclusion that they needed to somehow take this huge amount of tacit everyday human knowledge about the world, which we usually take for granted, and represent it in a set of formal rules they could spoon-feed the computer. It was nothing less than the attempt to create a symbolic representation of all our various, intricate, complex belief systems – essentially what makes us human – to store inside a computer.

Dreyfus' interest in language and how cognitive metaphors organize our daily experiences (as elaborated in Chapter Two) is evident in the way he shows that the problem of common sense is far more complex than the AI researchers imagined. It is not restricted to what people know, but extends to how they project and extend what they already know:

> Granted that an intelligent person can see analogies or similarities to what he or she already knows, there are several ways to think about this basic human capacity. The classic rationalist tradition since Aristotle has tried to understand analogies as proportions. A second tradition traces analogy back to our experience of our body. A third approach has reacted to the implausibility of the classical tradition by approaching analogy in terms of extrapolating a style. (Dreyfus, 1992, p. xxiv)

Similarly, when Searle tried to understand metaphors as proportions, he concluded:

> There are …whole classes of metaphors that function without any underlying principles of similarity. It just seems to be a fact about our mental capacities that we are able to interpret certain sorts of metaphor without the application of any underlying 'rules' or 'principles' other than the sheer ability to make certain associations. I don't know any better way to describe these abilities than to say that they are nonrepresentational mental capacities. (Searle, 1983, p. 95)

Dreyfus, following Heidegger, explains that this is because we are all masters in our everyday world:

> In our everyday coping we experience ourselves not as subjects with mental representation over against objects with fixed properties, but rather as absorbed in our current situation, responding to its demands. That said, it is not necessarily a world representation in our mind, since the best way to find out the current state of affairs is to experience the world as it comes, as we experience it. (Dreyfus, 1999, p. xxxi)

Dreyfus, citing Chapman, illustrates how we do this:

> If you want to find out something about the world that will affect how you should act, you can usually just look and see. Concrete activity is principally concerned with the here-and-now. You mostly don’t need to worry about things that have gone before, are much in the future, or are not physically present. You don’t need to maintain a world model; the world is its own best representation. (Dreyfuss, 1999, p. xxxi)

Employing Heidegger’s phenomenological approach, Dreyfus contends that the problem with trying to replicate human intelligence is not that it leaves out long-range planning or internal representations of re-indentifiable objects with context-free features (‘categorization’), but that it mainly lacks what every intelligent system needs: the ability to learn from experience and to discriminate, using the relevant distinctions that appear to come naturally to human beings and, as such, are taken for granted. According to him:

> Most of our skills involve action in evolving situation and are learned from trial-and-error experience with environmental feedback but without teachers (or, sometimes, from experience-based fine-tuning of what we initially learned through instruction). Moreover, while experts generally cannot access any information explaining their ability, they can usually assess the value or desirability of a situation

> easily and rapidly and recommend an appropriate action. (Dreyfus, 1999, p. xli)

According to Katrin Weigmann:

> The prevalent thinking in the 1950s or 1960s was that cognition involved the manipulation of abstract symbols [and] could follow explicit rules. Information about the physical world could be transformed into symbols and processed according to a set formal logic. As such, because symbol processing is abstract, it is independent of a platform. Scientists therefore claimed that cognition is similar to computation: minds run on brains as software runs on computer hardware. (Weigmann, 2012, p. 1066)

The ambitious aspirations in the field of AI were built on the false notion that human intelligence could be replicated in record time. They were symptomatic of the celebrated phrase attributed to Herbert Simon (1916-2001): “Machines will be capable, within twenty years, of doing any work a man can do.” Such optimism culminated later on in what was known as the ‘Dark Ages of AI’. Warwick (2012) observes that after the initial excitement – which was fuelled by substantial research funding, mainly awarded on the basis of the promise that replication of human intelligence would be soon achieved – the optimism within the field began to falter (as did the funding) as many of the claims and expectations of the 1960s failed to transpire.

For Warwick (2012), one of the main problems of the AI enterprise was limited computing power: even in terms of the restricted requirements of computation at the time, there was not enough memory, speed or computing capacity to run even basic processes. Simple tasks, such as getting a computer to communicate in a natural language or to recognize the content of a picture in anything like a human way, required a lot of information and processing power.

These limitations would not be overcome until much later. But over and above this physical limitation is the fact that, as Dreyfus outlines, what human beings regard as common-sense reasoning also demands, in theory, a lot of background information.

Things started to change when the field began to attract the interest of philosophers. For example, Searle, with his ‘Chinese room’ argument (discussed in the first chapter), explained that even when a machine manipulates symbols, it could not be described as ‘thinking’. Turing’s ideas of intelligence were more about computation and symbolic manipulation, whilst Searle argued that symbolic manipulation did not mean that computers understood what they were manipulating. Computers can manipulate symbols, but cannot attach meaning to these symbols.

However, according to Warwick (2012), there was a lone, dissonant voice at the time: John McCarthy (2004) refuted the idea of the development of human-centric artificial intelligence, as he considered that what humans do is not directly relevant to AI. McCarthy believed what was needed were machines that could solve problems, not computers that could display intelligence in exactly the same way as people do. However, Warwick says that it was in the 1980s that the field of AI began to experience a revival. He attributes this to three factors. First, many researchers, influenced by McCarthy, started to develop AI projects with a practical aim, creating expert systems to deal with specific applications in the industrial domain. This helped them avoid getting stuck in the ‘lack of common-sense’ argument. Secondly, the practical AI proposed by McCarthy ran parallel to all the philosophical discussions; the two schools of thought simply proceeded with their own work independently, systematically avoiding the claim that computers should or could think or behave like human beings. Thirdly, the development of robotics started to exert a substantial influence on the field. As Warwick observes:

> In this respect a new paradigm arose in the belief that to exhibit 'real' intelligence, a computer needs to have a body in order to perceive, move and survive in the world. Without such skills, the argument goes, how can a computer ever be expected to behave in the same way as a human? Without these abilities, how could a computer experience common sense? So, the advent of a cybernetic influence on AI put much more emphasis on building AI from the bottom up, the sort of approach, in fact, originally postulated by McCulloch and Pitts. (Warwick, 2012, p. 6)

Warwick (2012, p. 10) continues: "In the real world, humans interact with the world around them through sensors and motor skills." From this point, the concept of a brain as a sort of standalone entity no longer dominated AI:

> What is of considerable interest now, and will be even more so in the future, is the effect of the body on the intellectual abilities of that body's brain. Ongoing research aims to realising an AI system in a body – embodiment – so it can experience the world, whether it be the real version of the world or [a] virtual or even simulated world. (Warwick, 2012, p. 10)

Other areas of research include a biological approach – growing artificial brains from living biological neural tissue ('bio-inspired AI') – that is no longer based on computer systems. As Pfeifer and Scheier observe:

> Rodney Brooks suggested that all the discussion about thinking, logic, and problem solving was based on assumptions that come from our own introspection, from how we tend to see ourselves. He suggested that we drop these assumptions, that we do away with thinking and with what people call high-level cognition and focus on the interaction with the real world. Intelligence must have a body. Brooks called it 'embodied intelligence'. (Pfeifer and Scheier, 2001, p. xii)

Pfeifer and Bongard (2007) understand that embodiment enables cognition or thinking; it is a prerequisite for any kind of intelligence. The body is not something troublesome that is simply there to carry the brain around, but is essential for cognition.

Another consequence of these developments concerning the idea that the embodied condition enables cognition, thinking or the manifestation of intelligence is the increased interest of philosophers in the field of AI, and the introduction of discussions around models of intelligence, whether it be human, animal or artificial.

The reconceptualization of intelligence

The historical evidence within the field of artificial intelligence suggests that the biased, limited and human-centric view of intelligence was partially responsible for pushing AI towards its isolation and its so-called ‘Dark Ages’. By contrast, the embodied view of intelligence systematically denies that artificial human-centric intelligence can be developed in the absence of a human body.

This research suggests, however, that intelligence is not a property that belongs to something, be it a machine, an animal or a human being, but is something that happens ‘in between’ these entities. Intelligence emerges through interaction, and as with cognition, it is both situated and distributed. As the second chapter demonstrated, contemporary developments in the cognitive sciences, particularly in the area of embodied cognition, foreground these aspects of how intelligence is understood. The paradigm of the embodied mind shifts the idea that intelligence is something that belongs solely to an individual agent, whether human or non-human, to a conception of it as emanating from the agent’s interaction with an intricate set of conditions.[18] The interpretation of intelligence as situated, sensitive to context, and driven by the agent's activity within its environment also implies that intelligence is manifest through interaction.[19]

Defining intelligence

Arguably, this conceptualization of intelligence is not a literal one, as it lies within the scope of cognitive psychology, neither does it refer to intelligence as a quality that belongs to or empowers human beings alone; inspired by the philosophy of artificial intelligence, it argues that intelligence is a manifestation that 'emerges' out of favourable conditions. In other words, intelligence occurs through interaction.[20]

The field of AI (and its history) offers several perspectives on the interpretation of intelligence which create an appropriate theoretical context for developing this research.

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[18] This argument is developed in Chapter Five, with the ideas of Latour, Heidegger, Bateson and Malafouris, and the principle of symmetry.

[19] This point that intelligence is manifested through interaction between agents is elaborated further in Chapter Four with the example of the 'Turk', the mechanical chess-player. When we also understand intelligence as not only a human quality but one that can also be attributed to animals or artificial agents (such as machines that in their own way manifest and express intelligence), this opens the way for a reinterpretation of how intelligence is situated. The expression 'situated' is not utilized here simply in terms of human agents interacting with the world, but also in terms of human beings interacting with non-human entities, as well as interactions between non-human entities, refuting the dualism that suggests a hierarchy between non-humans and humans (see Chapter Five). Looked at in these terms, we cannot say categorically what intelligence really is. The Turk machine described in the next chapter suggests that machines create cognitive conditions that allow intelligence to be manifested through interaction, but also argues that machines need to be designed more intelligently. Influenced by the ideas of Licklider, it suggests that machines should take on the cognitive tasks that human beings are not so good at; in other words, computers or machines can be intelligent in their own way. If they are therefore supposed to be artefacts that amplify our capacities, our interaction with computers needs to be softened and become more 'symbiotic'; the boundaries of the hierarchy need to be broken. This is what the Turk, as an experiment, does. Material engagement is also important to Malafouris and Renfrew (2010, p. 01) in terms of the "transformative potential of things in human life". He suggests that material entities "make up our everyday worlds of thought and action". Thus, human beings should be more than 'operators', but should 'perform' with computers as cybernetics suggests (as outlined in Chapter Five).

[20] This topic was also discussed in the first chapter, with the examples of the Turing test and the 'Chinese room' experiment.

According to Pfeifer and Scheier:

> Intelligence has always been a controversial topic. Science fiction stories involving intelligence robots abound. Super-intelligent machines have, for a long time, been the stuff of nightmares. Computers and, even more so, robots have inspired people's fantasies. Because of the enormous developments in digital electronics and microtechnology in recent years, true artificial intelligence seems to be drawing near. So it is not really surprising that discussions concerning artificial intelligence are often highly emotional. (Pfeifer and Scheier, 2001, p. 3)

Pfeifer (2001) explains that what we consider intelligent depends on our expectations. Most human beings can talk, and some also play chess, but you could say the same about an animal; talking and playing chess are not extraordinary feats, and such abilities are not attributed to the possession of an extraordinary intelligence. However, if a child plays chess at a high level, he is considered to be very intelligent. But it does not only depend on our expectations: even if someone playing chess against a computer loses, he/she can still argue that they were *really* playing, whereas the computer was using its enormous mechanical computing power to sort through alternatives in a completely unintelligent way. In fact, there is no real agreement on what constitutes intelligence.

According to Warwick (2012), everyone has their own interpretation of intelligence, based on their individual experiences and personal views. It depends on the individual's judgment as to what is important. Warwick (2012, p. 13) also emphasizes the situated-ness of the concept when he says that it is affected by change: "What may be deemed to be intelligent at one time and place may not be so deemed later or elsewhere." According to Piaget (1963, p. 6), "[i]ntelligence is assimilation to the extent that it incorporates all the given data of experience within its framework … There can be no doubt either, that mental life is also an accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements.” On the other hand, Minsky (1995) understands intelligence as “the ability to solve hard problems”, while for Kurzweil (2000), “[i]ntelligence is the ability to use optimally limited resources – including time to achieve goals”, and McCarthy (2004) contends that “[i]ntelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.”

Warwick argues:

> Clearly, intelligence in humans is important but it is not the only example of intelligence and we must not let it override all else. If we are comparing intellectual ability between humans, then standard tests of one type or another are useful. However, we need here to consider intelligence in a much broader sense, particularly if we are to investigate intelligence in machines. (Warwick, 2012, p. 14)

Intelligence can be the ability to reason and to profit by experience. An individual’s level of intelligence is determined by a complex interaction between their heredity and environment, but, paraphrasing Warwick, we need to consider intelligence in a much broader sense, particularly if we are to investigate intelligence in machines.

When considering this greater range of possibilities, one important aspect to take into account is the fact that intelligence can be found in living beings other than humans. According to Pfeifer and Scheier:

> Animals (and humans, for that matter) can survive in highly complex environments, and they sometimes display astounding behaviors. Termites build fantastic towers, and bees dance [to] communicate, in

> sophisticated ways, the location of food sources. Other animals use tools in skilled ways. Certain vultures hurl a stone at an ostrich egg to break it. Galapagos woodpecker finches probe for termites. Primates exhibit sophisticated social behavior. We cannot help attributing some kind of intelligence to these creatures and those that engage in similarly sophisticated survival behaviors. (Pfeifer and Scheier, 2001, p. 11)

Some species therefore present very complex and sophisticated intelligent behavior. They can communicate, adjust themselves intelligently to their environment, and display initiative and the capacity to plan, learn, reason, and so on. One classic example – an object of scientific study for many years – is the dance routine of bees. According to Warwick, all these capabilities can be extremely difficult to give a value to if human beings cannot interpret the messages they convey:

> Bees exhibit individual behavioral characteristics within a tightly knit society. They appear to communicate with each other by means of a complex dance routine. When one bee returns from a pollen collection expedition, it performs a dance at the hive entrance, wiggling its bottom and moving forward in a straight line. The distance moved is proportional to the distance of the pollen source and the angle moved indicates the angle moved indicates the angle between the source and the sun. In this way, others bees can learn which is a good direction to fly. (Warwick, 2012, p. 14)

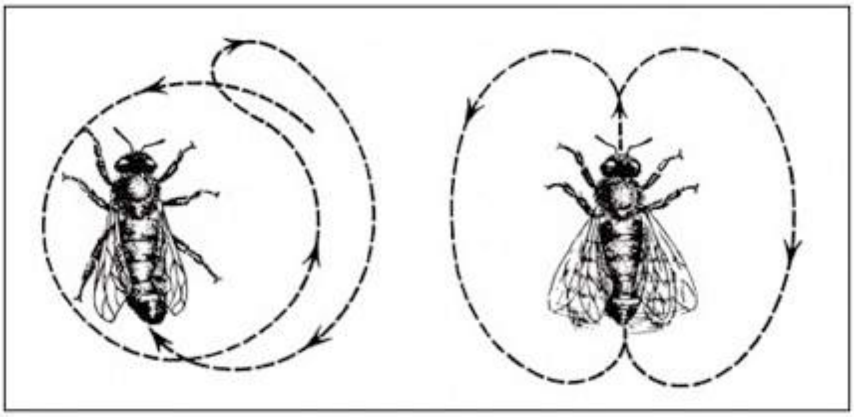

Fig. 7 The Waggle dance: The dance routine of the honeybee is known as the ‘Waggle dance’. It consists of a specific, complex dance, describing a figure of eight, by which the bee communicates with other members of the colony and shares crucial information relating to their environmental adaptation and survival.

Although the bee dance is a good example of non-human intelligence, it is unintelligible to any human being without specialized knowledge, and if viewed from a human perspective in accordance with human values. For example, the intelligence manifest in the behavior of the honeybees and their dance routine can be appreciated only by bearing in mind the limits of their organisms.

As mentioned above, it is now recognized that the body plays an important role in human cognition, as opposed to past perspectives which, in the main, located intelligence solely in the individual’s brain. The human body not only enables us to sense, experience and understand things in the world, but it also imposes constraints. These constraints are the limits of our embodied condition. As Pfeifer and Bongard (2007, p.19) state, “the body is not something troublesome that is simply there to carry the brain around, but it is necessary for cognition”.

Warwick (2012) argues that, as humans, our senses are limited; they take in a limited range of input. Our perception of the world is therefore limited by our physiological bodies – there is a lot going on around us that we cannot perceive. Intelligence of course is crucial for the adaptation of the individual, but it does not depend solely on the functions of the brain; we perceive things through our senses and thus activate the world around us:

> The success of a being depends on it performing well, or at least adequately, in its own environment. Intelligence plays a critical part in this success. Different creatures and machines succeed in their own way. We should not consider that humans are the only intelligent beings on Earth; rather, we need to have an open concept of intelligence to include a breadth of human and non-human possibilities. (Warwick, 2012, p. 17)

In this respect, there are two important things to consider in terms of intelligence: first, the fact that as humans, we have limited possibilities in terms of how we experience the world that surrounds us; and secondly, there are a set of non-human possibilities that can also be intelligent or at least can mediate our interaction with the environment in intelligent ways.[21]

This particular idea – to explore the ways human and non-human intelligence cooperates, with a view to extracting the best qualities of this cooperation – was developed by Licklider in the 1960s. Licklider (1960) came up with the idea of 'man-computer symbiosis' as a development in cooperative interaction between human beings and electronic computers. It was a bio-inspired idea which held that computers could facilitate thinking – as they now facilitate the solution of formulated problems – in a way that would enable human beings and computers to cooperate in making decisions and controlling complex situations without an inflexible dependence on predetermined programmes. Although Licklider never envisaged

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[21] In Chapter Five, it is also suggested that humans do not only operate machines or computers, but they act and perform with them.

machines replacing humans, he has been credited as an early pioneer of cybernetics and AI. He explains the concept of symbiosis in the following fashion:

> The fig tree is pollinated only by the insect *Balstophaga grossorum.* The larva of the insect lives in the ovary of the fig tree, and there it gets its food. The tree and the insect are thus heavily interdependent: the tree cannot reproduce without the insect; the insect cannot eat without the tree; together, they constitute not only a viable but a productive and thriving partnership. This cooperative “living together in intimate association, or even close union of two dissimilar organisms” is called symbiosis. (Licklider, 1960, p. 4)

Licklider’s hopes were that, in not too many years,

> […] human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machine we know today. (Linklider, 1960, p. 4)

According to Licklider, once in a symbiotic partnership, human beings could set the goals and formulate the hypotheses needed to perform evaluations and the machines could operate the routine work, and together they could create insights that could support human decisions in technical and scientific thinking. Licklider’s ideas reveal some distinctive insights that could be developed further. First, the idea that computers can display ‘intelligence’ is, in one respect, aligned with the ideas that took AI beyond the dead-end of GOFAI. His insight was about more than just collaboration, it concerned recognition of the qualities that both humans and non-humans manifest in the cooperative performance of the sorts of intelligent activities that neither could perform alone. Licklider did not privilege any sort of ‘intelligence’, but conversely –applying a 'Latourian' conceptualization of symmetry[22] – he understood the qualities and limitations of both the human and non-human and how they could cooperate. Of course, Licklider's ideas cannot be applied in the way that he first imagined, and neither can they be taken literally: they must be interpreted in a more contemporary way.

Licklider's ideas find this more contemporary interpretation in the work of Andy Clark. Clark states that we are all "natural born cyborgs":

> For we shall be cyborgs not in the merely superficial sense of combining flesh and wires but in the more profound sense of being human-technology symbiotes: thinking and reasoning systems whose minds and selves are spread across biological brain and nonbiological circuitry. (Clark, 2003, p. 3)

He continues:

> The cyborg is a potent cultural icon of the late twentieth century. It conjures images of human-machine hybrids and the physical merging of flesh and electronic circuitry. My goal is to hijack that image and to reshape it, revealing it as a disguised vision of (oddly) our own biological nature. For what is special about human brains, and what best explains the distinctive features of human intelligence, is precisely their ability to enter into deep and complex relationships with nonbiological constructs, props, and aids. This ability, however, does not depend on physical wire-and-implant mergers, so much as on our openness to information-processing mergers. Such mergers may be consummated without the intrusion of silicon and wire into flesh and blood, as anyone who has felt himself thinking via the act of writing already knows. (Clark 2003, p. 5)

Clark challenges the concept of the human mind as the only physical organ of reasoning. In his terms, we are not restricted by the boundaries of our biological skins, but we are so prone

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[22] Bruno Latour's (1994, 1999) conceptualization of symmetry is mentioned in Chapter Five.

to think that mental action happens exclusively inside us that the idea seems absurd. Clark understands that the human mind is not only situated in the head, but extends into the world – the smart world that we have created for ourselves. For Clark (2003, p. 10), “[as] technology becomes portable, pervasive, reliable, flexible, and increasingly personalized, so our tools become more and more a part of who and what we are”. Indeed, such tools are “best conceived as proper parts of the computational apparatus that constitutes our minds” (*ibid.*, p. 6).

In fact, in the contemporary world, much of our competence and intelligence is evaluated according to how we operate and deal with computers, laptops, cell phones and digital artefacts. We have pejorative definitions of people who do not understand or cannot deal with technology well, calling them, for example, ‘computer illiterate’. According to Warwick, this happens because

> [… a] strong social bias runs through such human educational systems and this can result in completely different values associated with subject areas. A group’s view of intelligence arises from a consensus between individuals who hold similar social and cultural beliefs and share common assumptions. Everyone’s concept also partly reflects their own personal qualities. Sometimes we do not give value to non-human abilities, partly because we do not understand them. (Warwick, 2012, p. 19)

However, it is important not to take a radical position when it comes to defining intelligence. Of course, intelligence plays an important part in the ability to be successful or perform adequately in one’s own environment, but as Warwick (2012, p. 17) points out, “[h]umans are able to manipulate the world in various ways ... Each being has different abilities in this respect”. It is not appropriate to say someone or something is not (or is less) intelligent because they cannot do some specific task:

> Different creatures and machines succeed in their own way. We should not consider that humans are the only intelligent being on earth; rather, we need to have an open concept of intelligence to include other organisms and non-human possibilities. (Warwick, 2012, p. 17)

Intelligence also has more subjective attributes. One of the interpretations gaining ground is the importance of the intuitive or emotional aspect of intelligence. The most well-known proponents of these concepts are the neuroscientist Antonio Damasio and the American psychologist Daniel Goleman. According to Pfeifer and Bongard, emotions and intuition play as important a role as rational intelligence:

> We continue to place this premium on rational intelligence despite the recent surge of interest in emotional intelligence, which argues that rationality is limited and that we should also take emotions into account when measuring intelligence. In other words, in this view, intuition and the ability to emotionally judge a situation is considered just as important as the 'cold' kind of intelligence required to pass high school exams or to achieve high scores on intelligence tests. (Pfeifer and Bongard, 2007, p. 12)

As we have seen, intelligence is a complex entity. How intelligence is interpreted also depends on the particular viewpoint of social groups, the cultural and social context, and common understandings shared between members of a society. The human tendency to look at things from a biased perspective creates social stereotypes that are incredibly difficult to dislodge. What a society deems worth knowing shapes the way that people look at knowledge and how they choose what to learn and how to articulate it on a daily basis. Warwick (2012, p. 17) observes: "Why is it that knowledge about politics, classical music or fine arts is seen by some to be more indicative of intelligence than knowledge about football, pop music or pornography?". The answer, he believes, is because we tend see everything in terms of human value sets, applying subjective measurements that are also extended to other creatures and machines. As humans, we give value to things by applying human ‘standards’ within our cultural context, simply because we are human beings and therefore give value to the things we do as human beings. Put in simple terms, it is difficult for us to give value to what other creatures or machines do unless they are merely mimicking what humans can do. This human-centric view contaminated AI for years. According to von Foerster:

> Projecting the image of ourselves into things or functions of things in the outside world is quite a common practice. I shall call this projection “anthropomorphization”. Since each of us has direct knowledge of himself, the most direct path of comprehending X is to find a mapping by which we can see ourselves represented by X. This is beautifully demonstrated by taking the names of parts of one’s body and giving these names to things which have structural or functional similarities with these parts: the “head” of a screw, the “jaws” of a vise, the “teeth” of a gear, the “lips” of the cutting tool, the “sex” of electric connectors, the “legs” of a chair, a “chest” of drawers, etc. (von Foerster, 2003, p. 169)

AI and cybernetics: fundamental differences

The characterization of the fundamental differences between artificial intelligence and cybernetics is important for the context of this research for two main reasons. First, this thesis demonstrates that the model applied to understanding how intelligence works is exemplified by machines such as the 18th-century chess-playing automaton, the Turk, and it elucidates, through the examples of ventriloquism and puppetry, ideas that complement those developed in cybernetics.[23] A parallel is built through comparison: both disciplines show individual qualities and limitations that, when combined, illuminate different aspects of HCI.

The second reason is the fact that one discipline (AI) has been more inclined towards representation, whereas the other (cybernetics) has been concerned with a completely different approach, more inclined towards a theory of performative action, with deeper concerns about environmental adaptation. That said, cybernetics emphasizes machines that 'act', to the detriment of machines that 'think'. AI, on the other hand, privileges a model that stresses the importance of knowledge, where a formalized model of the world is stored inside the agent or machine, enabling the manifestation of intelligence. Some of the concepts mentioned comprise part of the framework developed in the following chapters, where they will be explained more fully.

According to Pangaro (2006), the term 'cybernetics' first gained popularity in 1947 when Norbert Wiener adopted the term to describe a field that touched on established disciplines such as electrical engineering, mathematics, biology, psychology, neurophysiology and anthropology, but was also a discipline in itself. Pangaro (2006) argues that AI differs in many respects to cybernetics; they are not the same thing:

> Artificial Intelligence (AI) grew from a desire to make computers smart, whether smart like humans or just smart in some other way. Cybernetics grew from a desire to understand and build systems that can achieve goals, whether complex human goals or just goals like maintaining the temperature of a room under changing conditions. (Pangaro, 2006)

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[23] The Turk chess player and the concepts behind ventriloquism and puppetry are developed in more detail in the following chapters.

But, according to Pangaro (2006), there are even deeper underlying conceptual differences between the domains, some of which are captured in the diagram below:

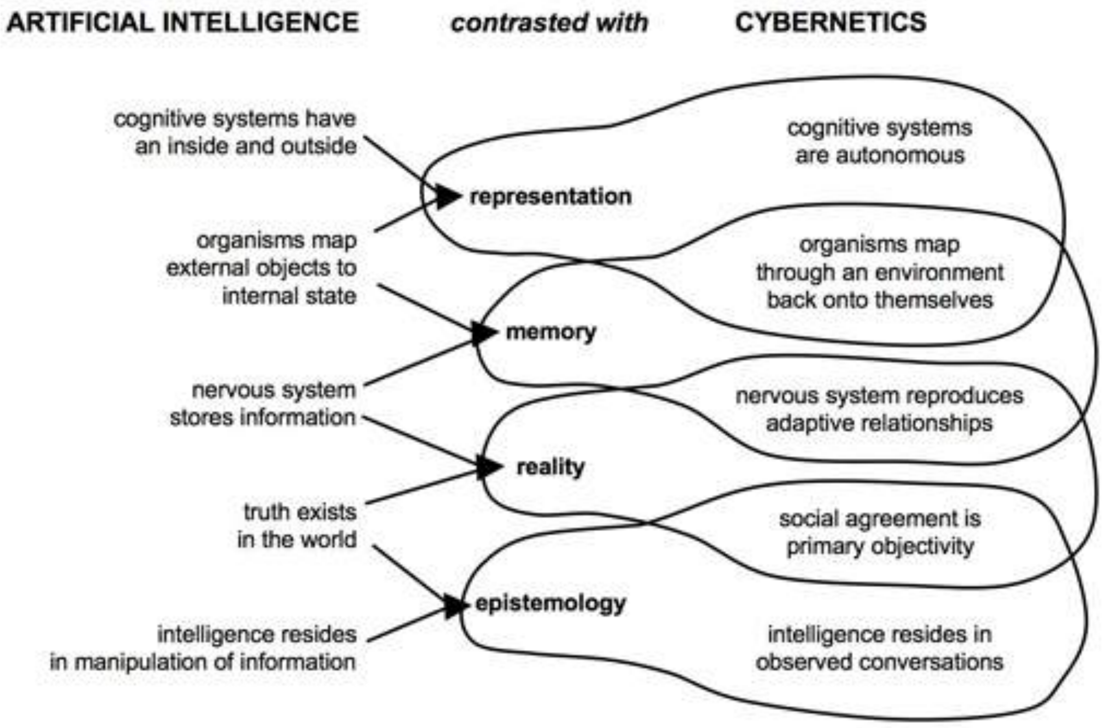

Fig. 8 Diagram comparison between AI and cybernetics © Paul Pangaro, 1990

Pangaro (2006) contends that while both fields share some concepts, such as those of representation, memory, reality and epistemology, they exhibit more differences than similarities. For example, on the one hand, AI holds that understanding the world is not only possible but also necessary; on the other, cybernetics argues that it is simply necessary (and possible) to be sufficiently connected with the world in order to achieve certain goals. Pangaro explains:

> The field of AI first flourished in the 1960s as the concept of universal computation (Minsky, 1967), the cultural view of the brain as a computer, and the availability of digital computing machines came together to paint a future where computers were at least as smart as humans. The field of cybernetics came into being in the late 1940s when concepts of information, feedback, and regulation (Wiener, 1948) were generalized from specific applications in engineering to systems in general, including systems of living organisms, abstract intelligent processes, and language. (Pangaro, 2006)

Basing physical systems on engineering concepts and their early applications helped to clarify the fundamental concepts of cybernetics, as well as the relevance of understanding that this functional model was common to all systems, including social systems. In this sense, cybernetics is the ‘science of observed systems’. Those working in the field also discovered that cybernetics could be applied to the process of cybernetics itself. The science of observed systems cannot be divorced from what von Foerster (1974) calls the “science of observing systems”, once the role of the human observer is taken into account. This discovery is often characterized as representing a milestone in the development of the discipline from ‘first-order’ to ‘second-order’ cybernetics. According to Pangaro (2006):

> The cybernetic approach is centrally concerned with this unavoidable limitation of what we can know: our own subjectivity. In this way cybernetics is aptly called ‘applied epistemology’. At minimum, its utility is the production of useful descriptions, and, specifically, descriptions that include the observer in the description. The shift of interest in cybernetics from ‘observed systems’– physical systems such as thermostats or complex auto-pilots – to ‘observing systems’ – language-oriented systems such as science or social systems – explicitly incorporates the observer into the description, while maintaining a foundation in feedback, goals, and information. (Pangaro, 2006)

Pangaro (2006) explains that AI and cybernetics alternate in terms of their influence on the history of the search for machine intelligence. Cybernetics started in advance of AI, but AI took over and dominated the field from the 1960s through to the mid-1980s, when its failure to achieve its promised goals culminated in GOFAI and its ‘Dark Ages’. AI researchers tried, without success, to create models of the world. Pangaro (2006) citing Minsky (1968), says they acted “with the presumption that knowledge is a commodity that can be stored inside of a machine and that the application of such stored knowledge to the real world constitutes intelligence”. They tried to create semantic networks and also worked with the implementation of expert systems. By contrast, cybernetics, according to Pangaro,

> […] evolved from a ‘constructivist’ view of the world (von Glasersfeld 1987), where objectivity derives from shared agreement about meaning, and where information (or intelligence for that matter) is an attribute of an interaction rather than a commodity stored in a computer (Winograd & Flores 1986). (Pangaro, 2006)

These differences are not merely a matter of semantics, but fundamentally determine the guidelines for conducting research in these two disciplines. Cybernetics is interested in the performative nature of the brain, the mind and the self, contrasting with the representational notions espoused by AI. The concept of representation in cybernetics is rather different, as can be seen in the diagram above (fig. 7). As Pangaro explains:

> Relations on the left are causal arrows and reflect the reductionist reasoning inherent in AI’s ‘realist’ perspective that via our nervous systems we discover the-world-as-it-is. Relations on the right are non-hierarchical and circular to reflect a ‘constructivist’ perspective, where the world is invented (in contrast to being discovered) by an intelligence acting in a social tradition and creating shared meaning via hermeneutic (circular, self-defining) processes. (Pangaro, 2006)

AI has been more inclined towards creating representations of intelligent phenomena in order to artificially replicate them. Cybernetics, however, is not preoccupied with understanding living entities in terms of representation; instead, it concentrates on the practicality of the interaction that might be achieved by action upon matter, interaction with materials, and the relations between the human and the non-human. As such, it is a science that prioritizes action in preference to a more symbolic, manipulative approach. It recognizes the existence of the body, because the world is not only an internal model or representation but also comprises the body's environment.

These philosophical positions fundamentally divide AI and cybernetics. It is interesting to note how cybernetics, autopoeisis and embodied cognition seem to share the same concepts. According to Pangaro (2006), it was under the influence of Maturana (1970) and Maturana and Varela (1988) that cybernetics shifted the approach away from the perspective of AI, basing itself on Maturana's interpretation of the concepts of 'language' and 'living systems'. Winograd and Flores (1986, p. 45), for example, cite Maturana's rejection of AI's information-processing metaphor as the basis for cognition:

> Learning is not a process of accumulation of representations of the environment; it is a continuous process of transformation of behaviour through continuous change in the capacity of the nervous system to synthesize it. Recall does not depend on the indefinite retention of a structural invariant that represents an entity (an idea, image or symbol), but on the functional ability of the system to create, when certain recurrent demands are given, a behaviour that satisfies the recurrent demands or that the observer would class as a reenacting of a previous one. (Maturana, 1970, p. 45)

If it wants to progress, it is crucial that HCI takes into account the comparison between AI and cybernetics, distinguishing between the models of human cognition and their different nuances. Both disciplines are represented in the following chapters, with AI represented by the Mechanical Turk – a hoax machine that simulates playing chess. The example of the Turk allows us to explore aspects of materiality and experience, situated-ness and intelligence – all elements that have direct implications for an understanding of human computer interaction.

Chapter Four

Automatons, Machines and Interaction:

Intelligent Manifestation of Ingenious Devices

> *Man is about to be an automaton; he is identifiable only in the computer. As a person of worth and creativity, as a being with an infinite potential, he retreats and battles the forces that make him inhuman.*
>
> William Orville Douglas

Prologue: Humanity's fear of its own machines

Brenda Laurel[24]

Human Computer Interaction is obviously one scientific area of computer science where there is a great commotion and [which] delivers a high degree of anxiety. Human Computer Interaction puts together designers, programmers, psychologists and people from different backgrounds and levels of expertise to think how people and machines can interact in better and more efficient ways.

On one side there are programmers, designers, engineers, psychologists and scholars trying to understand the other side called [in a] rudimentary [way], 'the users'. Using a computer graphical interface modelled and based on the understanding of human behaviour, the science of Human Computer Interaction tries to anticipate human actions and goals, creating restrictions and constraints to avoid human error and consequent frustration, helping users to reach their goals, whether at home or at work in their daily activities. That said, computer interfaces also accommodate human behaviour, fears, anxieties and also their limitations. What is supposed to connect both sides – human and computer – separates instead, imposing serious limits and restrictions.

Computer engineers, designers and developers might not notice these limits and restrictions. They are very absorbed with technicalities and in reaching their pragmatic goals. They live in a world dictated by numbers, codes and algorithms that need to fit into budgets, which need to generate incomes and profits. There is also a political layer, as well a strong cultural bias behind it, caused by different backgrounds and people with divergent understandings about how computers work or should work. There is an entire industry and also books to be

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[24] Laurel, B. (1990). *The Art of Human-Computer Interface Design*, Addison-Wesley.

sold with the new trends of how interaction between humans and computers can be improved by new methods, rules and techniques.

They are also specialists victimized by the software and hardware culture dominance. They are born in a world where the rules are already determined. They can just keep following the flow, fitting in to rigid standards difficult to change. One software runs under another software that needs to be run in a way where there is no space for creativity or expressiveness, because obviously, it also presents constraints.

Add to that [the fact that] that human behaviour is not linear. It is not predictable enough. It fluctuates and changes to accommodate the complex world we live in. We improvise. Humans don't know how to make the world fit into our machines very well. How to use the right tone of voice, language, how to store and accommodate 'common sense' inside the machine. How [to] try to create 'artificial' world-models. Humans also do not understand themselves very much and that is why they don't understand computers either. Humans understand aspects of computation, but not very much about what escapes from the boundaries of logic, what constitutes intuition, creativity and imagination and how to formalize it. They try to accommodate their emotional aspects in terms of stimulus-response, in terms of input and output. So, humans create constraints to keep things in control. That is what HCI is all about. This is the scenario.

Introduction

The following chapter is presented in two parts. The first uses Standage's (2002) book, *The Turk: The Life and Times of the Famous Eighteenth-Century Chess-Playing Machine*, to explore the secrets of the fascinating machine know as the 'Mechanical Turk', or simply the 'Turk', made by Wolfgang von Kempelen in 1770. For many years, before it was finally revealed to be a fraud, the Turk simulated an automaton that could play authentic games of chess.

In the second part, the chapter develops connections between the characteristics of this artefact as an analogy of cognition and our interaction with objects and machines. Although the Turk was an illusion, constructed purely for the amusement of its audience, it is used here to explore ideas and concepts about the relationship between materiality, physicality and cognition, connecting mind, body and environment within a model of a distributed and embodied mind. The chapter proposes a critical way of thinking about human computer interaction, using the early automaton as a model to explore how intelligence is manifested through interaction. Although partially dedicated to the mythologies of artificial automatons and mechanical machines, its key concern is with HCI development and design, and it seeks to amplify our comprehension of various aspects of the relationship between human beings and machines by analyzing the Turk in order to clarify relevant research concepts.

Although von Kempelen's automaton was an elaborate hoax, the mechanical chess player speaks eloquently of the harmonious cooperation between the (human and mechanical) elements responsible for presenting it in such a way that it appeared to the audience as a seamless unity, rendering the trick itself invisible. The Turk continued to play chess, intimidating its opponents, for more than seven decades. Even in von Kempelen's time, the invisible power of this ingenious and elaborate device stimulated discussion and ideas concerning artificial intelligence, raising questions about whether a machine could be more intelligent than a human being and whether logical thinking could be mechanically formalized, as well as suggesting a range of other philosophical queries (Standage, 2002).

The Turk exemplifies the proposition that it is possible to explain how users actively think ‘distributively’ through devices (or objects) as part of an interactive solution, rather than simply developing interaction based on representations. Drawing on this model, the chapter uses images of the Turk to illustrate concepts that are applicable to the contemporary development of HCI, presenting a model of the mind as ‘embodied’ (Hutchins, 2010, p. 426) and the possibility of interactions using the intelligence of the ‘artificial’ world and focusing on the physicality of the ‘medium’. The chapter advocates thinking *through* devices as an alternative in the development of HCI. This is not just a simulation of the world as in, for instance, the dominant graphical user interface (GUI) paradigm, but it uses the world itself, regarding it as its own best ‘representation’ and therefore as central to the cognitive process.[25]

Mechanical dreams

An automaton (a mechanical self-operating machine) and Automatons (or automata) have been part of the intellectual history of artificial intelligence for centuries. *“The term automaton is also applied to a class of electromechanical devices – either theoretical or real – that transform information from one form into another on the basis of predetermined instructions or procedures”* (Franchi and Güzeldere, 2005, p. 27). According to Standage:

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[25] Winograd and Flores (1986) have developed this idea further, expanding on Heidegger’s challenge to the dominant view of the mind, by arguing that cognition is not based on the systematic manipulation of representations, which denies the physical basis of human action.

> Automata are the forgotten ancestors of almost all modern technology. From computers to compact-disc players, railway engines to robots, the origins of today's machines can be traced back to the elaborate mechanical toys that flourished in the eighteenth century. As the first complex machines produced by man, automata represented a proving ground for technology that would be harnessed in the industrial revolution. (Standage, 2002, p. 2)

According to Franchi and Güzeldere (2005, p. 26): "The claim that we can understand human nature by finding out about the mechanisms of its embodiment has been around for many centuries"; the roots of AI reach back over time, not only in academic thinking but also in the public imagination. Franchi and Güzeldere argue that the automaton did not carry, in itself, the ambition of making intelligent devices, although it is fundamental to what later became the conceptual basis for the development of AI. Automatons, according to these authors, were used to emphasize the imitation of the desired *external* behavior, neglecting the function of the *internal* mechanisms that could, in principle, be imbued with attributes such as intelligence and autonomy.

Automatons were also considered the predecessors of electronic robots, and they came in various incarnations: monks, writers, musicians or animals. To give a small sample of these forms, three such curious machines are shown in the images below. One of the most famous automatons is the 18th-century life-size replica of a tiger mauling a British soldier, discovered in Tipu Sultan's summer palace in 1799 in Mysore, India, and then dispatched to Britain. Hence, it is known as Tipu's Tiger.

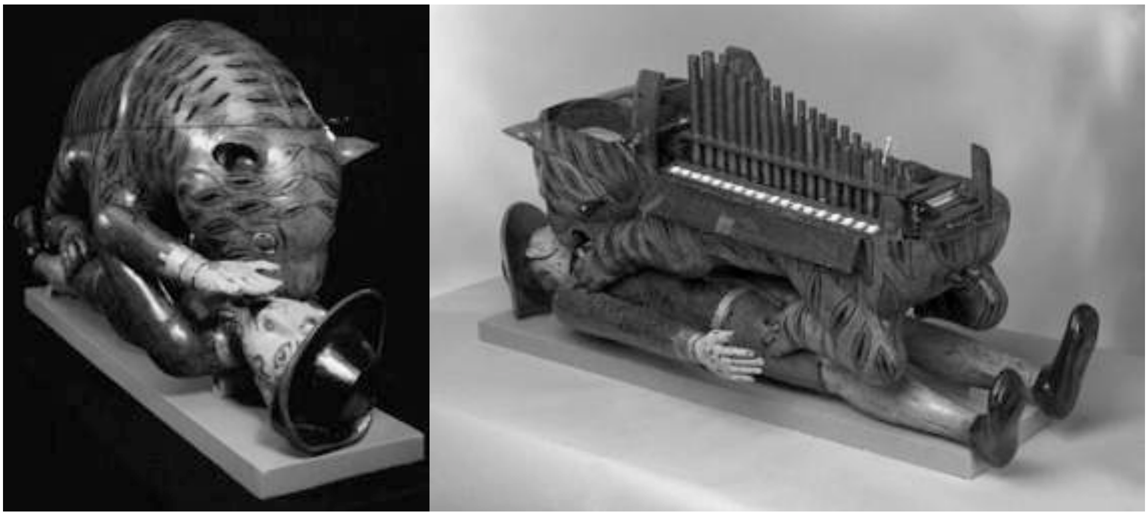
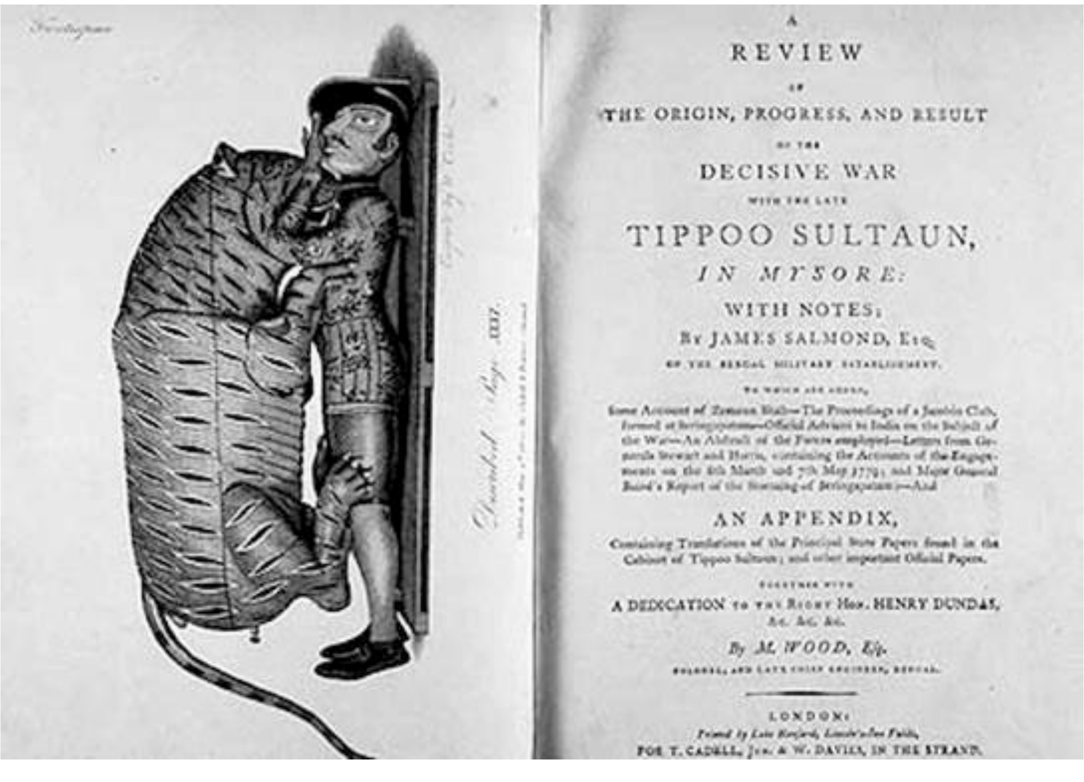


Fig. 9 Tipu's Tiger or Tippoo's Tiger: According to the V&A's (2011) catalogue: "Tipu's Tiger is an awesome, life-size beast of carved and painted wood, seen in the act of devouring a prostrate European in the costume of the 1790s. It has cast a spell over generations of admirers since 1808, when it was first displayed in the East India Company's museum."



A
REVIEW
OF
THE ORIGIN, PROGRESS, AND RESULT
OF THE
DECISIVE WAR
WITH THE LATE
TIPPOO SULTAUN,
IN MYSORE:
WITH NOTES;
By JAMES SALMOND, Esq.

AN APPENDIX,
Containing Translations of the Principal State Papers found in the Cabinet of Tippoo Sultaun; and other important Official Papers.

A DEDICATION TO THE RIGHT HON. HENRY DUNDAS,
&c. &c. &c.
By M. WOOD, Esq.

LONDON:
FOR T. CADELL, Jun. & W. DAVIES, IN THE STRAND.

Fig. 10 An illustration of Tipu's Tiger in an account of the British defeat of Tipu Sultan, co-authored by Colonel Mark Wood in 1800, which haunts contemporary images of the tiger.

Another emblematic automaton came in the form of a duck. Created by Jacques de Vaucanson in 1739, it was known as the ‘*Canard Digérateur*’ or the ‘Digesting Duck’. The duck was an intricate piece of engineering, with more than 400 moving parts in each wing. It could flap its wings, drink water and eat kernels of grain, and was able to simulate digestion. According to Standage (2002, p. 7), “Vancauson was particularly interested in building machines capable of imitating the natural processes of living beings, including respiration, digestion, and the circulation of the blood”.

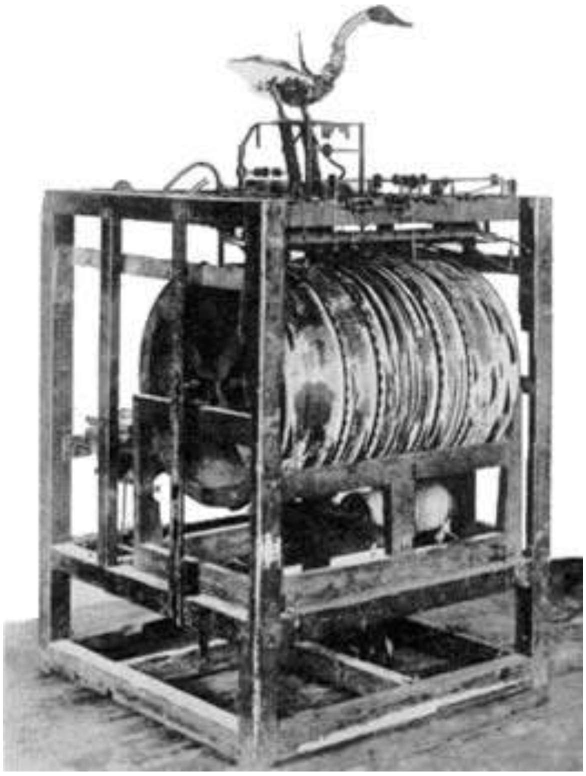


Fig. 11 The Digesting Duck: an automaton created by Jacques de Vaucanson in 1739. The duck was an intricate and sophisticated work of engineering.

Fig. 12 The Draughtsman, the Musician and the Writer: three automatons built by Pierre Jacquet-Droz, his son, Henri-Louis, and Jean-Fréderic Leschot between 1768 and 1774.

We can also add the work of Pierre Jacquet-Droz to these emblematic examples. Between 1768 and 1774, Jacquet-Droz built, with the help of his son, an automaton known as 'The Musician'. It became the first of a collection of three automatons, which included not only the female organ player, who could play her custom-built instrument quite well, but also a draughtsman who could draw four different images (a portrait of the French royal family; a dog with the inscription, '*Mon Toutou*' ('My Doggy'); and Cupid driving a butterfly chariot), and a writer, a young child who also moved on his chair and occasionally blew on his pen to remove dust. This last automaton was considered to be the most complex: he used a goose-quill pen, which he inked from time to time, and could write any text of up to forty characters (these were coded onto a wheel from which they could be individually selected).

The variety of machines and automatons built over the centuries is almost countless, but one of the most famous and most enigmatic automatons ever built is Wolfgang von Kempelen's chess-playing machine, the Turk. According to Sussman (1999), the Turk was constructed in response to a challenge:

> It began in 1769 with a challenge, or perhaps a boast, made by the Hungarian engineer and mechanician Farkas de Kempelen, born in 1734, in response to the arrival of a French inventor named Pelletier at the court of the Empress Maria Theresa of Austria. Pelletier's exhibition of "certain experiments of magnetism" prompted de Kempelen to suggest that he could produce "a piece of mechanism, which should produce effects far more surprising and unaccountable than those which she then witnessed" (Oxford Graduate 1819: 12). Six months later he appeared before the Empress with the Automaton Chess Player, also known simply as the Turk. (Sussman, 1999, p. 87)

The chess-playing machine built to impress the Empress of Austria, however, was an ingenious fake. The Turk was in fact secretly operated over the years by various talented chess masters, and in this way, it was able to simulate playing very high-level games of chess against human opponents. For decades, the competitors believed they were pitting themselves against an authentic automaton. According to Sussman:

> The Chess Player was a dramaturgical hybrid of theatre, magic, and science, presented by an exhibitor – at once stage illusionist, conjurer and prestidigitator, sideshow talker, and mechanical engineer – and employing a choreography of momentary concealment and subsequent revelation, generating in the attentive observer alternate responses of skepticism at the impossible and belief that the secret of the trick, like the pea in the shell game, would be revealed. Like a traditional puppeteer, the exhibitor possessed a mix of verbal and manual dexterity, the reverence for objects and their capacity for enchantment. (Sussman, 1999, p. 83)

He continues:

> The life-sized figure was dressed in a fur-trimmed cloak and turban and held a long pipe in its right hand, its left arm resting on a pillow. The figure was seated at a large mahogany chest about a meter wide, 80 cm high and 60 cm deep, with two swinging doors and one long drawer in its front. With the assistance of its exhibitor, it would publicly compete with volunteer players, using its mechanical arm to lift each chess piece and drop it into its new position (Hooper and Whyld 1984: 363). With its downcast eyes and mustache, the figure suggested the Orientalist fantasy of a sorcerer or fortune-teller. (Sussman, 1999, p. 83)

The Turk was capable of convincing an audience that it could play chess, and therefore that it was able to formalize logical thought mechanically, albeit in a very restricted domain. Its secret – the human chess master inside its cabinet operating it in such a way as to produce a mechanical illusion of autonomy – persisted undisclosed for decades. As Sussman observes:

> De Kempelen’s Automaton Chess Player was a technological mysterium, a secret to be uncovered, and a riddle to be solved, whether it won its game or lost to its volunteer opponent. … [W]e could add an ancestor from the prior century: the mechanical puppet, costumed as a Turkish sorcerer, moving a chess piece from one square to another, conscious (or so it appeared) of the rules of the game. (Sussman, 1999, p. 83)

When the automaton was exhibited, the show began with the ‘revelation’ of its inner mechanism, a set of moves intended to convince the spectator that its intelligent machinery was on display. As its true secret was never publicly revealed, and there appeared to be no reliable explanation of its success, it inspired a great deal of conjecture about how it actually worked. According to Reilly:

> While the Turk appears as a deceptively simple mechanical trifle, constructed for the pleasures of the aristocracy, it is actually a theatrical object upon which the historical and discursive practices of

> Orientalism are staged. The automaton Turk was a bagatelle or playful illusion composed of working clockwork machinery: the left hand that held his pipe, the right hand that moved the chess pieces, and the noisy clockworks whirring inside his spine all provided concealment, keeping audiences from realizing that the ghost in the machine was no ghost at all. (Reilly, 2011, p. 4)

Standage (2002) dedicates an entire chapter to explaining and describing the Turk’s secret, which had stimulated so many decades of speculation. According to Standage, it was only in 1857 that an authoritative account appeared, written by Silas Wier Mitchell, whose father had been the Turk’s last owner. This appeared in the form of a series of articles entitled ‘Last of the Veteran Chess Players’, published in a New York magazine, *Chess Monthly*.

> Silas Mitchell’s description of the account was based on his own recollections and some notes made by his father. It repeats a number of myths about the Turk (such as it having played against George III and Louis XV) and contains several errors relating to the manner of the Turk’s presentation. But Mitchell’s articles, together with other documents dating from the Turk’s last days in Philadelphia, make possible a full explanation of the automaton’s secret. … As had been widely suspected, the Turk was indeed controlled by an operator concealed inside the cabinet, who remained there throughout the performance. There was no need for wires or pieces of catgut, nor for trapdoors beneath or behind the automaton. Nor was the automaton’s strategy guided in any way by the artful use of exterior magnets. (Standage, 2002, pp. 194-180)

Standage concludes that the fact that the exhibitor, standing outside the cabinet, had no direct control over the automaton’s actions or strategies made the trick appear more plausible.

Wolfgangs von Kempelen
k. k. wirklichen Hofraths
Mechanismus
der
menſchlichen Sprache
nebſt der Beſchreibung
ſeiner ſprechenden
Maſchine.

Mit XXVII Kupfertafeln.

Haſce igitur penitus voces cum corpore noſtro
Exprimimus, rectoque foras emittimus ore,
Mobilis articulat verborum dædala lingua,
Formaturaque labrorum pro parte figurat.
Lucret. lib. IV. v. 553.

Wien,
bei J. B. Degen, 1791.

Fig. 13 Von Racknitz’s book on the Turk

In an earlier bid to discover the Turk’s secret, Joseph Friedrich Freiherr von Racknitz (1744-1818) published a book based on his own observations (*Ueber den Schachspieler des Herrn von Kempelen, nebst einer Abbildung und Beschreibung seiner Sprachmachine*), with illustrations explaining how he believed the Turk operated (fig. 13). His assumptions, however, were later proved wrong (Standage, 2002, pp. 198-99).

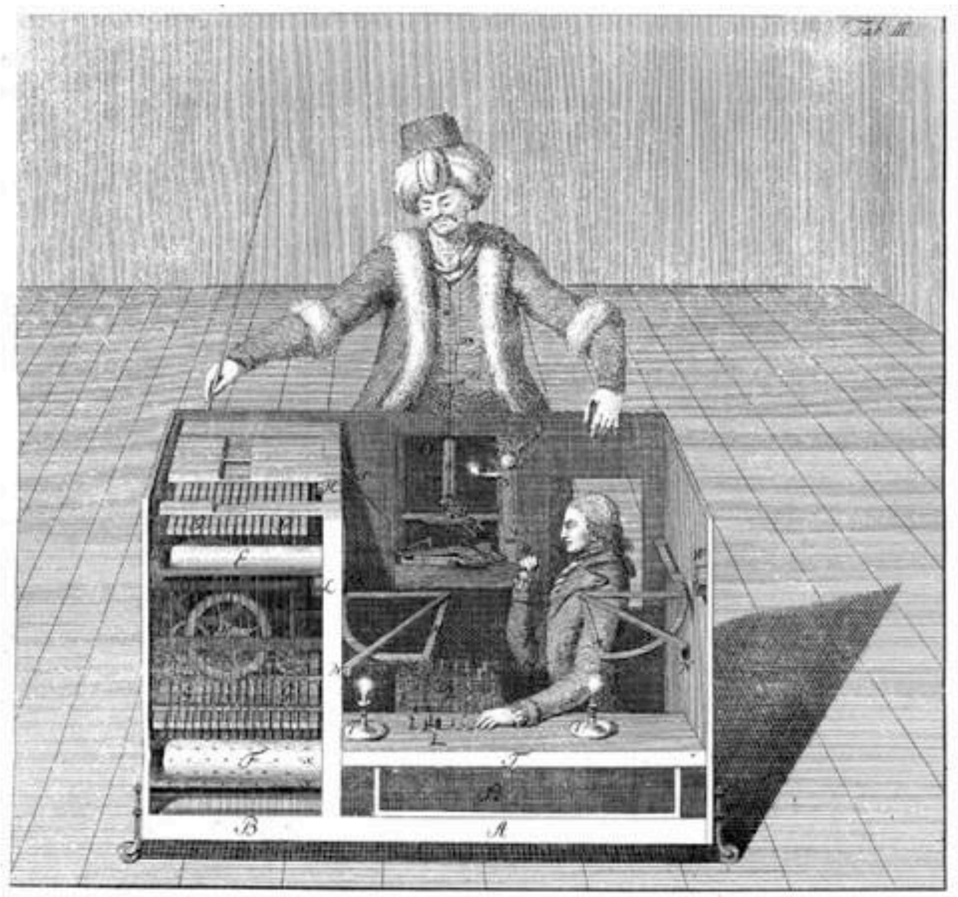


Fig. 14 Von Racknitz’s wrong assumptions about the Turk

According to Standage:

> Racknitz wrongly concluded that the operator had to fit solely into the space behind the machinery; there was even enough room for the operator to sit up. So there was no need for the operator to be a child, a dwarf, or an amputee; the cabinet was capable of concealing a full-size adult. … The clockwork machinery visible on the Turk’s left-hand side (as seen by the audience) did not extend all the way to the back of the cabinet, behind the drawer was pulled out, it appeared to have the same depth as the cabinet. (Standage, 2002, p. 87)

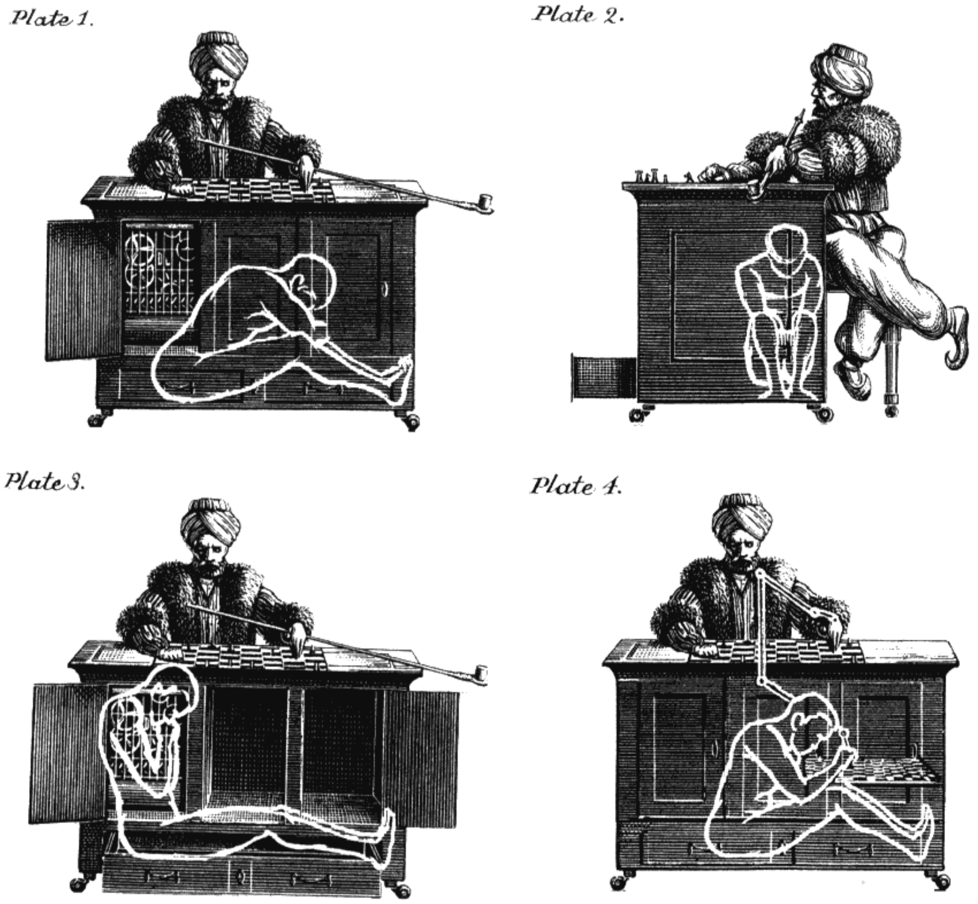


Fig. 15 Standage's plates illustrating the way the Turk worked

The secrets of the Turk are explained in detail in Standage's (2002, pp. 198-99) book using four specific plates (fig. 15):[26] "The base of its secret was a sliding seat that can be moved

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[26] The secrets of the Turk explained by Standage (2002, pp. 198-99):
Plate 1: "At the start of the performance, the operator moved forward on the sliding seat. The movement of the seat caused a small amount of dummy machinery visible through the cabinet's leftmost door (as seen by the audience). It was then possible for the exhibitor to open the small door at the back of the cabinet and hold a lighted candle up to it, whose flickering could just be seen through dense machinery that now seemed to extend all the way to the back of the cabinet."
Plate 2: "Once the exhibitor had removed the candle and shut the rear door, the operator straightened his legs and slid backward on the moving seat. This caused the dummy machinery to fold up and also closed a small window behind the front-most machinery through which the light of the candle had shone. This ensured that there was no danger that the operator, now sitting up behind the clockwork machinery that was still visible to the audience, would be seen."
Plate 3: "The operator now had to prepare the cabinet's main compartment for inspection by the audience.

back and forth by the operator, opening and closing various folding partitions.” Although a detailed description is not essential for an understanding of the argument developed in this chapter, it clarifies some of the questions and ideas (stimulated by the machine) which appear in HCI and design development, including how cognition can be distributed among agents and the materiality of the machine.

Cognitive and distributed power as manifested in the Turk

According to Standage (2002, p. 224), computers are unquestionably the modern descendants of automatons: they are ‘self-moving machines’, in the sense that they blindly follow a preordained series of instructions – although, rather than moving physical parts, computers move information. Just like automatons, computers operate at the intersection of science, commerce and entertainment. They have also given rise to an industrial revolution of their own by extending human mental (as opposed to physical) capacity. Observing the interaction of human agents with the Turk, for example, gives an insight into the materiality of objects and renders its importance for cognition, and human computer interaction, more explicit.

As Willis had suspected, the main compartment, which was lined with green baize, was not as simple as it seemed. After sitting back, the operator covered his legs by folding over a lid that formed part of the main compartment’s floor; then he concealed his body by closing a door that formed part of the main compartment’s floor … [and] a door that formed part of the main compartment’s side. This ensured that the main compartment resembled an almost empty box. By pulling on a string, and hooking its end over a button, the operator then raised into place the small amount of machinery, including wheels, cylinders, and brass quadrants, that was situated in the main compartment. Again, this machinery was a decoy and had no useful function.”

Plate 4: “All of this took a few seconds, however, so the exhibitor did not immediately open the cabinet’s front doors. Instead, he opened the drawer and slowly and deliberately removed the chessmen. Have done so, the exhibitor could then open the doors of the main compartment and reveal its almost empty interior. Next, he would open the door at the back of the main compartment and reveal its almost empty interior. Next, he would open the door at the back of the main compartment and introduce a candle, so that the spectators could inspect the main compartment. The exhibitor then spun the whole contraption around and opened the doors in the back of the Turkish figure to reveal more decoy machinery.”

During its short history, the field of HCI has been responsible for making our interactions with technology – more specifically with computers – more friendly and natural. An analysis of the Turk reveals that it shared some of these aspects, illustrating an alternative model of the mind. Used as a model for HCI, it suggests a range of possibilities that need to be considered, including a more ‘embodied’ and ‘external’ interpretation of cognition, rejecting the predominant computational approach. Thus, some of the observations question the limits of the representational and computational (GUI) paradigm.

One element manifested by the Turk was the materialization of cooperation between all the elements involved. The way it was designed suggests that von Kempelen had a full and detailed understanding of all the constituent parts of the automaton, not only its natural elements, but also the artificial and mechanical harmony that was manifested so eloquently in the machinery in order to perform the trick and to respond the user’s ‘needs’. Although he could not have been aware of the contemporary discussions of HCI, it is curious to note von Kenpelem’s concerns with the machinery in terms of its design and applicability, and the harmonious interaction between all its elements. In order to perform the trick in a convincing, synchronized manner, he generated a device where human cognition was distributed between the people involved (inside and outside the cabinet) and the artefact (the Turk itself). The fraud he perpetrated relied on a structure that promoted interaction between the elements, human and non-human, inside and outside. This interaction resulted in a chess game, where not only the challenger but also the chess master inside the cabinet manipulated the chess pieces and exercised their cognitive capacities in a common pursuit. As Hutchins (1995, p. 288) reminds us, “the heavy interaction of internal and external structure suggests that the boundary between inside and outside, or between individual and context, should be softened”.

What von Kenpelem conceptualized was, in a sense, the creation of an artificial environment where intelligence[27] could be manifest and cognition could be distributed across the material and cognitive properties produced by the interaction among the parts. Hutchins (1995, p. xvi) calls this aspect "cognitive power", and continues, "the environments of human thinking are not 'natural' environments. They are artificial through and through. Humans create their cognitive powers by creating the environments in which they exercise those powers." In harmony with Hutchins' idea, the chess-playing machine gave informed feedback and possessed an eloquent transparency based on its own structural form, generating a restricted terrain for human inference:

> A good deal of what needs to be done can be inferred from the structure of the artefact, which constrains the organization of action of the task performer by completely eliminating the possibility of certain syntactically incorrect relationships among the terms of the computation. … Rather than amplify the cognitive abilities of the task performers, or act as intelligent agents in interaction with them, these tools transform the task that the person has to do by representing it in a domain where the answer or the path to the solution is apparent. (Hutchins, 1995, p. 155)

In fact, the Turk suggests a solution based on task specialization, restricting the interaction to the machine's physical structure and materiality. When it comes to desktop computers, what springs to mind is how the complexity and openness of the human project called 'personal computers' turned into a more ambitious project with far higher expectations. Computers have indeed become just such a viable project, but one that is based more on the flexibility, ability and cognitive competence of the user than on the characteristics and qualities of a

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[27] Michael Punt (2002, p. 366), for example, describes a taxi-cab as not only a "transporter of bodies between destinations, but … a complex data storage and retrieval system. Not quite an artificial intelligence machine, since it needs a sentient human processor, but nearly." His idea suggests that we might also consider systems like the Turk as manifestations of intelligence distributed within a number of elements.

system apparently designed to be more user-friendly and accessible to programmers, designers and ordinary users.

It seems impossible to deny that representational GUI is a model that will persist as a basis for computers for several more years. However, it can be observed that this paradigm is changing, with the addition of a second level of interaction in GUI that is opening up new possibilities, simulating materiality and operating according to a logic of cause and effect when stimulated by an external force or agent (for example, responding to gestures like pinching or tapping, or the use of such technology as accelerometers). These provide a different model of interaction, using the best of both worlds. This link between the two worlds – the material and the digital – provides an alternative to the abstract manipulation of representations. Putting together graphic representation and mechanical or physical aspects suggests a model where most of us can share the experience of 'being in the world', as Heidegger famously put it.[28]

This condition, also present in von Kempelen's Turk chess player, highlights a fundamental difference between the digital world and the 'real' world. The digital world is intangible, and its language uses a rhetoric that tries to simulate some of the aspects of the real world, making it intuitively congruent with what people assume is 'real'. Buttons appear to be pressed, pages simulate movement, and behaviors and resistances are predicted as they obey the fundamental and invariable laws of nature, or at least what is understood as such. As a result, they are more consistent with the mental model of the human user outlined in Chapter One. This has turned HCI into a discipline mostly concerned with anticipation and prediction, creating (in a sense) a model of reverse-engineering based on human behavior in order to

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[28] Clark (1997), Dreyfus (1972, 1992), Winograd and Flores (1986) are some of the authors that have used Heidegger's ideas extensively in their work, in order to understand computers, mind, cognition and also AI.

understand the human mind. The Turk, as a model, elucidates this point clearly: the automaton highlights an alternative, ‘enactive’ approach. This is the central argument against the way that traditional information-processing psychology understands perception as entirely internal, arising from within the individual. The enactive approach, by contrast, illustrates how perception not only depends on, but is also constituted by, our possession of the sort of embodied and embedded sensorimotor knowledge that is crucial to the understanding of cognition.

> Having failed to notice that the central metaphor of the physical-symbol-system hypothesis captured the properties of a sociocultural system rather than those of an individual mind, AI and information-processing psychology proposed some radical conceptual surgery for the modeled human. The brain was removed and replaced with a computer. This surgery was a success. However, there was an apparently unintended side effect: the hands, the eyes, the ears, the nose, the mouth, and the emotions all fell away when the brain was replaced by a computer. (Hutchins, 1995, p. 363)

The Turk, determined by the materiality of its components and the restricted domain of the chessboard and direct manipulation, offered the ‘user’ simple interactivity based on ‘real-world interaction’, creating space not only for the manifestation of the human mind through the machine, but also for the manifestation of sensorimotor knowledge and agency, promoting perceptual experience. Hutchins (1995, p. 228) argues that perceptual experience depends on sensorimotor contingency – that is, there is a causal dependence of experience on action: “Perceptual experience, according to the enactive approach, is an activity of exploring the environment, drawing on knowledge of sensorimotor dependencies and thought.” As an artefact, the Turk possessed the quality of promoting this reconciliation where “[t]he computational constraints of the problem have been built into its physical structure” – not just through a simulation of the world (as, for instance, in the dominant GUI paradigm) but, paraphrasing Holt, by using “the world itself as its best representation” and therefore as central to the cognitive process.

Physicalism: towards a tangible experience

Another perspective that also shows this reconciliation between the Turk and our cognitive processes, using the world itself as its ‘best representation’, is the research developed by Dourish (2001, p. 36) that give us “an opportunity to think about the boundary between the physical and virtual worlds as a permeable one”.

Dourish (2001) argues that as computing has moved beyond the traditional boundaries of the desk, incorporating attempts to bring the physical and social world into our daily computer experience, we need to develop a historical view of interaction in order to understand the range of human ability and skills, and incorporate them into our interaction with computers. Although any sort of ‘ethnographic’ or ‘social’ approach is not a central concern in the context of this thesis, Dourish’s research holds similarities with the content of the arguments put forward here. For example, he also systematically refuses the narrow perspective of the mental models discussed in Chapter One, and explores the concept of cognition within an embodied perspective:

> This comes about in contrast to a narrowly cognitive perspective that, for some time, dominated the thinking of computer system designers and still persists to a considerable degree. The positivist, Cartesian ‘naive cognitivism’ approach makes a strong separation between, on the one hand, the mind as the seat of consciousness and rational decision making, with an abstract model of the world that can be operated upon to form plans of action; and, on the other, the

> objective, external world as a largely stable collection of objects and events to be observed and manipulated according to the internal mental states of the individual. From this perspective, a disembodied brain could think about the world just as we do, although it might lack the ability to affect it by acting in it. (Dourish, 2001, p. 18)

And he continues:

> [A d]isembodied brain could not experience the world in the same ways we do, because our experience of the world is intimately tied to the ways in which we act in it. Physically, our experiences cannot be separated from the reality of our bodily presence in the world; and socially, too, the same relationship holds because our nature as social beings is based on the ways in which we act and interact, in real time, all the time. So, just as this perspective argues that we act in the world by exploring its physical affordances, it also argues that our social actions are ones that we jointly construct as we go along. (Dourish 2001, p. 18)

According to Dourish, (2001, p. 101), “[e]mbodiment denotes a form of participative status. Embodiment is about the fact that things are embedded in the world, and the ways in which their reality depends on being embedded.” He explains that the notion of embodiment, although it plays a special role in terms of a contemporary understanding of cognition, is not new; it belongs to a particular philosophical school of thought known as phenomenology. Phenomenology[29] is a philosophical doctrine proposed by Edmund Husserl, which was based on the study of human experience, in which considerations of objective reality are taken into account. For phenomenologists, thinking does not occur separately from being and acting. As Clark explains:

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[29] Phenomenology is primarily concerned with how we perceive, experience and act in the world around us. What differentiates it from other approaches is its central emphasis on the actual phenomena of experience, where other approaches might be concerned with abstract world models. Traditional approaches would suggest that we each have an understanding of the elements of which our world is constructed, and an abstract mental model of how these concepts are related.

> The image of mind as inextricably interwoven with body, world, and action, already visible in Martin Heidegger's *Being and Time* (1927), found clear expression in Maurice Merleau-Ponty's *Structure of Behavior* (1942). … In particular, Merleau-Ponty stressed the importance of what I have called "continuous reciprocal causation"– viz., the idea that we must go beyond the passive image of the organism perceiving the world and recognize the way our actions may be continuously responsive to worldly events which are at the same time being continuously responsive to our actions. (Clark, 1999, xvii)

Dourish (2001, p. 2), in his research, uses the concept of 'tangible and social computing' to explain embodied interaction, as "these two trends – the massive increase in computational power and the expanding context in which we put that power to use – both suggest that we need new ways of interaction with computers, ways that are better tuned to our needs and abilities". He continues:

> In particular, they both exploit our familiarity and facility with the everyday world – whether it is a world of social interaction or physical artifacts. This role of the everyday world here is more than simply the metaphorical approach used in traditional graphic interface design. It's not simply a new way of using ideas like desktop, windows, and buttons to make computation accessible. Instead of drawing on artifacts in the everyday world, it draws on the way we experience the everyday world. Both approaches draw on the fact that the ways in which we experience the world are through directly interacting with it, and that we act in the world by exploring the opportunities for action that it provides to us – whether through its physical configuration, or through socially constructed meanings. In other words, they share an understanding that you cannot separate the individual from the world in which that individual lives and acts. (Dourish 2001, p.17)

Dourish (2001) argues that the notion that interaction is intimately connected with the environment – as this is where the interaction takes place – is on the increase among designers. Although he seems to be more concerned with the social organization of the workplace and how this affects work itself, giving to it a more ‘social approach’ (a theme that does not apply to the context of this research), the approach Dourish proposes, arguing that our daily interaction is also tailored by the details of the environment in which such activity takes place, connects with the previous discussions in this chapter relating to the Turk. Of course, it is difficult to delimit the boundaries between natural phenomena and the cultural organization of the workplace. However, Dourish argues that the physical settings where work activities occur, where it is possible to observe real users undertaking real activities, doing real work, are quite revealing, and provide a better way of understanding interaction than abstract accounts of mythical users or ‘persona’ (mentioned in Chapter One).

Dourish argues that interaction can be partially but not entirely explained by the physical properties of the world that we interact in, and he tries to reconcile the main aspects of ‘tangible computation’ with the trends of ‘social computing’:

> Tangible computing reflects these concerns by exploring the opportunities for us to manifest computation and interaction in radically new forms, while social computing seeks ways for interaction to manifest more than simply the programmer’s abstract model of the task, but also the specifics of how the work comes to be done. In the real world, where the artifacts through which interaction is conducted are directly embodied in the everyday environment, these are all manifested alongside each other, inseparably. Tangible and Social computing are trying to stitch them back together after traditional interactive system design approaches ripped them apart. (Dourish, 2001, p.19).

For Dourish, ‘tangible and social computing’ is a theoretical trend that tries to put these experiences back together, taking into account our familiarity with them, as the social and the physical are aspects that shape our everyday lives. He sees both as intertwined:

> As physical beings, we are unavoidably emmeshed in a world of physical facts. We cannot escape the world of physical objects that we lift, sit on, and push around, nor the consequences of physical phenomena such as gravity, inertia, mass, and friction. But our daily experience is social as well as physical. We interact daily with other people, and we live in a world that is socially constructed. Elements of our daily experience – family, technology, highway, invention, child, store, politician – gain their meaning from the network of social interactions in which they figure. (Dourish, 2001, p. 99).

It seems clear that our daily experience cannot be disconected from physical phenomena, but Dourish goes further and argues that our social experience is also physical, as the elements of our everyday experience gain meaning from the situated-ness of the experience of where it occurs.

Dourish traces this parallel by giving as an example the work of ‘tangible bits’, using computer rhetoric to describe the transition between the world of atoms to the world of bits and the transition from the physical to the virtual. The Tangible Media Group at the MIT (Massachusetts Institute of Technology) Media Lab is a research group that runs a program that incorporates perspectives of ‘ubiquitous computing’. Dourish (2002, p. 44) observes that “while digital and physical media might be informationally equivalent, they are not interactionally equivalent. By building information artifacts [*sic*] based on physical manipulation, the Tangible Bits programme [*sic*] attempts to reinvest these distilled digital essences with some of the physical features that support natural interaction in the real world.” The term ‘tangible bits’ reveals a direct focus on the interface between the physical and virtual worlds. The work on tangible bits provides some balance to the idea that a transition from atoms to bits is inevitable and uniformly positive. As Dourish observes:

> They reflect a holistic approach that takes full account of their physicality. The physical nature of these pieces is not simply a consequence of their design; it is fundamental to it. While it was a tenet of ubiquitous computing, for example, that the technology would move out into the world, the design pieces reflect a recognition that the technology *is* the world, and so its physicality and its presence is a deeply important part of nature. … [T]hey reflect a different perspective on the role of computation, in which computation is integrated much more directly with the artifacts themselves. (Dourish, 2001, p. 42)

The Turk and material agency

To understand why the rhetoric of materiality used to describe the Turk can help us understand interaction, it is necessary to turn to the work of Knappett and Malafouris (2008). Their book on 'material agency' is a compilation of articles on the subject of agency, human and non-human (this topic is explored more fully in Chapter Five). Knappett and Malafouris challenge the human-centred view that agency is purely a human property, and extend the concept to artefacts and environmental matter, giving a new meaning to the material world. Fundamentally, they reinstate the notion of material engagement – which aligns with the reconceptualization of intelligence that philosophers have introduced into the field of AI – and move away from the anthropocentric interpretation of agency by engaging with material culture. In the same way, Clark (1999, p. 171) explains, "Heidegger was opposed to the idea that knowledge involves a relation between minds and an independent world (Dreyfus 1991, pp. 48-51) – a somewhat metaphysical question on which I take no stand. But, Heidegger's notion of the milieu of embodied action is thoroughly social."

For Knappett and Malafouris:

> This human-centred view of agents and artefacts is not limited to those artefacts we design to be like agents. It extends to a much wider and more prosaic world of artefacts and matter, an environment of things that is conceived on our own terms, under our control and designed to serve. We do not give a second thought, on the whole, to chairs, mugs, steps, litterbins, wooden, ceramic, concrete or plastic: these objects are overlooked because we engage with them habitually and haptically every day. They would not serve our ends very well if we could not overlook them. Designed to be secondary, they have to be secondary, forming the backdrop to our lives, of which we are of course the stars, the decision-makers, the agents. It is common sense that agency should be conceived anthropocentrically – how can it be otherwise? We are centre-stage in our lives, not these artefacts, however mundane, or indeed intelligent. (Knappett and Malafouris 2008, ix)

Knappett and Malafouris' reconceptualization of 'non-human and material agency', when applied to the Turk chess player, gives it a new perspective and a more ambitious interpretation that can be perceived at first glance. They stress the centrality of material culture and artefacts (whether these be historical machines or their contemporary equivalents, computers) to an understanding of the material world:

> By using the term 'material agency' we do not want to go to the other extreme and say that agency is material rather than human; it is more of a wake-up call, for social scientists and archaeologists, to encourage them to consider agency non-anthropocentrically, as a situated process in which material culture is entangled. (Knappett and Malafouris, 2008, p. xii)

According to Malafouris and Renfrew (2010, p. 01), "[s]ince the early years of our childhood we constantly think through things, actively engaging our surrounding material environment, but we very rarely become explicitly aware of the active potential of this engagement in the shaping of our minds and brains”. Or put more simply, things have a cognitive life because minds have a material life.

Summary

The research in this chapter relates two elements – early automatons and the interaction between humans and computers – in order to discover what it is that speaks to us so eloquently in the Turk chess-playing machine that could help us rethink HCI.

The idea is not new: the notion of distributed, embodied and enacted cognition has been current for some time in the scientific community and holds similarities with the philosophy of phenomenology. The philosophical idea implying that a new concept of mind is needed to understand cognition and consciousness has been used to reframe several disciplines: in this research, it is used to reframe human computer interaction. Although HCI has achieved considerable commercial success, empowering users to undertake their own work and activities by using this sophisticated piece of engineering, thus promoting technological inclusion, much of what is known about HCI is based on the archaic notion of computation developed in cognitive science, which maintains that people behave like information processors and that the process of thinking is very similar to the process of computing. All the substantial changes in HCI have been contaminated by this idea, and it has transformed it into a discipline of incrementalism, displaying substantial resistance to users.

The analysis of the Turk in this chapter is an attempt to reconcile materiality, physicality and cognition, connecting mind, body and environment within the model of a distributed and embodied mind, through which our cognitive power can be manifested. To reiterate: it is through things that we think and interact, it is through artefacts that we actively engage with the world, not because things have a cognitive life, but because minds have a material life.

Chapter Five

Puppetry, Ventriloquism and Cybernetics:

Cyber-Performative Objects

Man is first animated by
invisible solicitations.

Saint-Exupéry

Prologue

Fig. 16 Corky (the ventriloquist), Fats (the dummy) and Ben Green (Corky's agent) in the film *Magic* (1978)

Corky: Yeah, I was kind of out of control back in the city. I uh... I could feel myself starting to slip down the iceberg.

Ben Green: So you took off? And now you're fine?

Corky: Sure. On account of Peg.

Fats: The local town pump, terrific knockers.

Corky: Look Fats, please. Come on, will ya?

Fats: Sorry.

Corky: I've known her ever since high school. I never figured I'd have a chance with her, but uh, now everything's changed. She believes in me.

Ben Green: Listen, girls are for down the line, kid. Right now, you gotta let me help you. I know a lot of people. Beautiful doctors.

Fats: He means headshrinkers. He just thinks you're a fruitcake.

Corky: He doesn't, he never said that, he's on our side.

Fats: He's the villain. Don't forget that. Never forget that.

Ben Green: Hey, kid. I'm gonna ask you to do something. It's a little something anybody ought to be able to do. Now if you can do it, fine. We'll forget this whole thing. But if you can't, we'll think about getting you to see somebody fast. Is it a deal?

Corky: Name it.

Ben Green: Make Fats shut up for five minutes.

Corky: Five minutes? I can make him shut up for five years.

Ben Green: Wonderful.

Corky: I feel like the village idiot, if you want to know the truth. Can we talk or is it going to be strictly semaphore? How long so far?

Ben Green: There's 30 seconds.

Corky: Gosh, that's uh... Four and a half minutes to go. Think I'll make it? Don't happen to have another of those, do ya? (*asking for a cigar*) Thanks.

Corky: "Take two, they're big." Remember when you said that, Ben?

Ben Green: A pro never forget his good lines, kid.

Corky: How long now?

Ben Green: Coming up to a minute.

Corky: Do you think we'll laugh about this some day?

Ben Green: We might.

Corky: Make a terrific scene if you ever decide to write your autobiography. Hey, you know what you should call it, um… ‘Failing Upwards’, or ‘How to succeed in show business, by outliving everybody’.

Corky: Two minutes yet?

Ben Green: A minute forty-five.

Corky: This is very cruel of you, you know that?

Ben Green: I don’t mean it to be.

Corky: I don’t know if I’ll ever be able to forgive you.

Ben Green: Well, that would be sad.

Corky: Time?

Ben Green: It’s uh... two-and-a-half minutes to go.

Corky: I can’t make it.

Ben Green: Well, I didn’t think you could.

Fats (*taken by Corky to speak through, frenetically*): Hello everybody. This is Mrs. Norman Main. My mother thanks you, my father thanks you, my sister thanks you, and I thank you. You have nothing to fear but fear itself. Nothing to give but blood sweat and tears. Nothing to lose but your change. Here he is, boys. Here he is, world. Here’s Fats.

Fats: You’re not letting him outta here. He is the villain, don’t forget that.

Corky: Hey, I think you better sit down.

Ben Green: Hey kid, I have lived through Tallulah Bankhead and the death of Vaudeville. I don’t scare easy.

Corky: But I need my chance.

Ben Green: Your only chance is to get help fast and that’s what I’m going to see happens.

Ben Green: Don’t ever raise a hand to me again.

Corky: You're taking my one chance.

Ben Green: I'm your one chance.

Fats: He's right. The Postman's right. You're crazy.

Corky: I tried to stop him didn't I?

Fats: Tried, tried? You failed. God damn it. Look at me. You know it's the hatch for you.

Corky: There's nothing wrong with me.

Fats: I know that, and you know that. But all those piss ant dolts who run the world, they hate us because we're special.

Fig. 17 Fats (the dummy) and Corky (the ventriloquist) in the film *Magic* (1978)

The text above was taken from the script of the film *Magic* (1978) and illustrates the dialogue between Corky (the ventriloquist), Fats (the dummy) and Ben Green (Corky's agent). *Magic*, which was curiously neglected by audiences at the time of its release, tells the story of a magician's assistant, Corky (Anthony Hopkins), who performs disastrously at his first solo presentation. In order to improve his performance, Corky begins to perform as a ventriloquist with a dummy called Fats, and within a few years he has reached the status of a minor celebrity. However, Fats seems to develop mind of his own and gradually wants to impose his 'evil' dominance over Corky. Corky begins to realize that fame and money are not all that he dreamed them to be. Then, when Corky finds that the contract requires him to submit to a medical examination, he refuses and runs away, retreating to a lakeside cabin owned by the woman he fell in love with in his early years. This is where most of the story unfolds, with tragically dramatic consequences.

The storyline of *Magic* (1978) suggests that the ventriloquist has basically split his own personality in two, and both sides want to impose their dominance. However, the film seems to keep this possibility deliberately ambiguous, so that it can operate as a dramatic element in the plot. It appears that Corky is suffering from schizophrenia and is using the dummy to manifest the things he is not able to express himself. However, in the process, the dummy has become more than just an extension of Corky's self; it is almost another 'living' entity.

The dialogue, cited above, from the scene in which Ben Green (played by Burgess Meredith) suspects Corky's sanity, demonstrates this symptomatic tension. Green asks Corky to put Fats aside for five minutes to prove he is not dominated by the dummy and can return to the stage without him, but Corky, after trying to stay away from Fats, realizes he is not able to. The dialogue develops to suggest that the psychological boundaries between the ventriloquist and his dummy have become uncannily blurred, almost non-existent. Corky has developed a *symbiotic* and *symmetric* connection with Fats: Fats can only speak through Corky, his master, but in the end it is Corky who cannot speak without using his dummy.

Green’s participation in the dialogue is also an example of the way in which a cybernetic system is structured and establishes itself: each action triggers a new series of events, which generate new changes within a closed system of circular causation. Who is the one really speaking in the end: the man activating the puppet or the puppet compelling the man to activate him? The relationship between the ventriloquist, his dummy and the agent is illustrative of how interaction operates, not only in terms of its choreography, but also in the way it is shaped by external intervention. It is not only Corky who appears to see Fats as another ‘living’ entity in the room, but also Green. Green is very disturbed by Fats’ disruptive interventions, seeing him as an obstacle to gaining Corky’s attention. Fats, however, brings Green and Corky together in such a way that they have access to each other – he is the medium or ‘interface’ between them. But in his role as an interface, Fats can also be rather disruptive; he sometimes connects the two and sometime separates them.

The dramatic strategy of the plot is to magnify Corky’s madness, his uncontrolled behaviour and schizophrenia. Although the dialogue is quite dystopic, the interaction between Corky, Fats and Green cannot be easily ignored, but deserves appropriate reflection. In these terms, it is interesting to keep in mind that the British variant of cybernetics was actually born in a psychiatric context,[30] involving thinkers such as Gregory Bateson and, later on, R.D. Laing.

The dialogue between Corky, Fats and Green can be used as an analogy of the different levels of operation in the cybernetics model. There is a level, for example, in which the computer is not under our command, but is commanding us. By tracing these parallels, this chapter is not arguing that human beings are now under the control of their machines or computers; rather, it is suggesting the existence of a sort of ‘dominance’. The word

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[30] Pickering (2010) emphasizes that although this first-generation cybernetics was born in the context of psychiatry, and despite its ramifications outside that field, it left clinical psychiatry itself largely untouched.

‘dominance’ is used here metaphorically, in cognitive terms (although it is not only restricted to cognition). Neither is it suggesting that this is necessarily a negative dominance, but one that is disruptive and not completely under human control. Indeed, it cannot be easily denied that there is – in cognitive terms – an intense relationship between human beings and computers or artefacts, especially in relation to how we perform with computers and the way this is reflected in our lived reality.

The computer, therefore, is not simply a tool that mediates ‘interaction’. In ventriloquism, for example, the dummy mediates, enables and stimulates the action between the ventriloquist and the audience, but there is something over and above this that has to be grasped. The relationship can be perfectly well understood in terms of cognitive processes, but these cannot cover all aspects of human complexity, especially when the subject under discussion is the ecology of artefacts and objects, and the interaction between all these entities. The following chapter unpacks these ideas.

Introduction

There is a sublime aspect to the performative nature of ventriloquism and puppetry that clearly reveals how human beings interact with artefacts and other objects. Historically, as artistic practices, they have been relegated to a minor niche of theatrical and artistic performance. In this chapter, however, they are brought into the foreground and used as a model through which to explore and understand contemporary theories of interaction.

The science of cybernetics explains this orchestration of humans and objects from the point of view of our cognitive capacities and interactive nature, and both practices – puppetry and ventriloquism – can therefore be characterized, in cybernetic terms, as systems regulated by information and feedback. It cannot be a coincidence that the performative nature of puppetry and ventriloquism bears a resemblance to cybernetics. This chapter contends that we can use these artistic practices as a framework to explore interaction and to reveal and clarify concepts such as human and non-human agency, symmetry and asymmetry, aspects of symbiosis, and the expansion of our cognitive boundaries. It argues that these concepts can be expanded into the domain of HCI and translated into design terms, to better understand the concept of interaction in relation to HCI specialization. It aims to stimulate enquiry and amplify our comprehension of human interaction with computers and digital artefacts. Through the work of scholars such as Pickering (2010); Pangaro (2010),; Licklider (1960); Maturana (1970); Clark (1997, 1998, 1999, 2001, 2003, 2008); Malafouris (2008); Latour (1994, 1999); and Bateson (1972), among others, the following chapter invites reflection on the connections between subjects and disciplines that at first glance do not appear connected, but which share a variety of perspectives on the same phenomenon.

A cybernetic view

It is particularly important to clarify the cybernetic model if we are to explore interaction and the way its performative nature resembles the idea of operative performance within cybernetics. According to Pickering (2010), American mathematician Norbert Wiener and his colleagues coined the term ‘cybernetics’ at the Macy Conferences held in New York between 1946 and 1953. It was derived from the Greek word for ‘governor’ (in the sense of ‘steersman’), so cybernetics can be read as ‘the science of steermanship’ or ‘the art of steering’. Pangaro (2006) points out that cybernetics as a concept has been around at least since Plato used it to refer to *government*. The idea of cybernetics as a discipline, however, was born with Wiener, and the name was adopted to evoke concepts such as action, interaction, feedback and response in all kinds of systems. What was fundamental about Wiener’s (1948) insight was his formalization of the notion of feedback. From the point of view of information transmission, Weiner held that the distinction between machines and living beings was simply a matter of semantics. The Wiener conceptualization of feedback displaced the old-fashioned idea of the mind as a causal mechanism by imposing a new paradigm, which argued that the learning process is analogous to a self-regulated, autonomous process in which a system emerges.

Cyberneticist pioneers such as Ross Ashby, Warren McCulloch, Grey Walter and Norbert Wiener were extremely interested in building machines in order to ‘see and learn’. Their philosophy was to avoid any previous enquiry, so that it could function as a theory that could sustain their practical decision to construct machines. Certainly, they were interested in developing a consistent theory to explain cybernetics, but they were not reticent in also imposing it at a practical level, building machines that could act and perform, so they could genuinely learn from them.[31]

The idea that cybernetics can be applied to explain basic processes is not entirely new. Cybernetics has been used to describe groups, organizations, leaning processes, design, political science and also living systems.[32] Cybernetics as ‘the art of steering’ held implications for several fields, including engineering, systems control, computer science, biology and philosophy, and was influential in some areas of research into the organization of society. Pickering (2010) has developed his own cybernetic understanding (contrasting with representational theories) with his interpretation of ontology, in which he understands the world as one of many dynamic entities evolving in performative interaction with one another.

In terms of human interaction with computers, there are two specific points in cybernetics that can be highlighted in the context of this chapter. The first is that the assumption that the representational model is all we need to understand interaction is a sort of fallacy, particularly in terms of the digital language that dominates our daily lives, our artefacts and tools. We are developing a new language for digital mediation that is predominantly attached to language and representation, and as a new language, it requires that the user either adapts or acquires new cognitive capacities, or at least that the language is instrumentalized for the sake of this new ‘domain’. As Suchman (2007, p. 34) points out, “[i]nteraction between people and machines implies mutual intelligibility or shared understanding”. The second is

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[31] Pickering’s book, *The Cybernetic Brain: Sketches of another future* (2010), explains what cyberneticists were interested in. It was written bearing in mind the practical level of the discussion. Pickering (2010, p.4) documents what he calls “ideas as engaged in practice” or “real world projects”, describing “what cybernetics looked like when people did it, rather than just though it”, and avoiding abstract discussion of the notion of ‘feedback’ and so on.

[32] Maturana and Varela explain the concept of ‘autopoiesis’ in their work, *Autopoiesis and Cognition: the Realization of the Living* (1980).

the potential cybernetics holds to free us of the responsibility of prediction when it comes to interaction and understanding our own limitations in opening the ‘black box’.[33] Cybernetics is thus a very liberating framework, in so far as providing a theory of HCI that is predominantly anti-representational is concerned.

Understanding the main differences between artificial intelligence and cybernetics is crucial in the context of this research. These fields represent two generations of cognitive science: the one concerned with embedding intelligence inside the agent and the other with understanding interaction with the environment as a crucial part of intelligence and its acquisition. One of the biggest mistakes in the field of AI was how slow the field was to recognize that there were not only human-centric ways of studying artificial intelligence. The result was the period called the ‘Dark Ages’ of research into AI (GOFAI), mentioned in Chapter Three, which lasted until the field was able to reinvent itself and re-emerge with new notions of intelligence that recognized the limitations of the promised artificial replication of human intelligence. AI did begin to recognize the centrality of the body in the attempt to create human-centric intelligence and intelligent agents.

Cybernetics and AI are complementary fields, but they have significant epistemological differences. Both approaches contrast with the traditional approach in HCI that emphasizes the abstract manipulation of symbols grounded in physical reality, and the manipulation of ‘reality’ itself, replicating the internal debate between the symbol-system hypothesis and the physical-grounding hypothesis.[34]

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[33] See the ontology of the black box.

[34] For more detail, see Brooks, R.A. (1990) ‘Elephants don’t play chess’. Robotics and Autonomous Systems, 6, pp. 3–15.

The performative nature of cybernetics

The characterization of performance as a way of understanding interaction is not new in the literature. However, there is often a significant difference in how theorists speak about the same subject from their different theoretical or personal perspectives. Laurel (1991), for example, underlines the performative nature of computers and advances the idea in relation to human interaction with computers, arguing that it needs to be tackled from the imaginative perspective of the dramatic arts, and not only by technical attribution. This avoids the dominance imposed by the field of computer science. Laurel’s humanistic approach highlights the use of Aristotle’s *Poetics* as a framework, situating the subject outside the domain of computer science and using enactment in drama to explain human-computer activity. She proposes the dramatic arts as an alternative way of addressing the problem of interaction, rather than embracing a perspective of it as a purely technical issue. Similarly, Similarly, Bolter and Gromala (2003) comment that people do not really use computers; rather, they ‘perform’ with them. They argue the medium itself is central to the explanation of our comprehension and experience of digital artefacts, and discuss the possibility of achieving a correct equalization between visibility and transparency.

The lens of cybernetics gives us the best view of the performative nature of ventriloquism and puppetry and the way they suggest that our interaction with the world is more sophisticated that is perceived in a first cursory analysis. The word ‘performance’ cannot be stressed enough when it comes to a comparison between AI and cybernetics. The ambition embodied in the AI project was certainly manifest in the moving automata that were sometimes made purely for entertainment purposes, such as the little marionettes in music boxes, or to make life easier by avoiding human labour (for example, irrigation devices).[35] But the initial ingenuity perceived in cybernetics occludes the fact that AI cannot totally embrace its specific (and its potential) virtues. Just as puppetry was restricted to a theatrical niche and relegated to the position of a low form of theatrical performance art, cybernetic theory also suffered from lack of academic prestige. It was downplayed by AI in the 1960s, mostly due to its inability to co-exist alongside AI in a single field, but also because of the new trend in symbolic AI.[36]

Pickering goes directly to the point when he portrays the cybernetician's conception of the brain as an immediately embodied organ, intrinsically tied into bodily performance, whose special role is purely *adaptive*. As Pickering (2010, p. 5) says, "[t]he brain is what helps us to get along and come to terms with, and survive in, situations and environments we have never encountered before". According to him, knowledge undoubtedly helps us to 'get along' and adapt to the unknown, but the cybernetic model of the brain was not only representational but also *performative*, and its role in performance was mostly *adaptation*:

> The key point that needs to be grasped is that the British cyberneticians' image of the brain was not this representational one. What else could a brain be, other than our organ of representation?

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[35] See *Mechanical Bodies, Computational Minds: Artificial Intelligence from Automata to Cyborgs* (2005), edited by Stefano Franchi and Guven Güzeldere. Franchi and Güzeldere (2005, p. 23) distinguish between AI and the larger project of artificial intelligence: "There are two different sets of limitations that set it apart from the broader project of artificial intelligence. The first one has to do with the technology used to reproduce intelligence skills. Needless to say, electronic digital computers are an invention of the twentieth century, and the history of mechanical or analogue computers does not go very far. But the more important difference between the current definition of AI and the larger project of artificial intelligence is the identification of intelligence with exclusively cognitive capacities (language, learning, reasoning, and problem solving). Forms of purposeful behaviours that lack a cognitive dimension are excluded. This particular way of delineating the domain of intelligence capacities is not without consequences."

[36] See Cariani, P. (2010) 'On the importance of being emergent. Book review of Clark, B. and Hanson, M.B.N. (2009) *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Durham: Duke University Press, 2009'. *Constructivist Foundations* 5(2): 86-91.

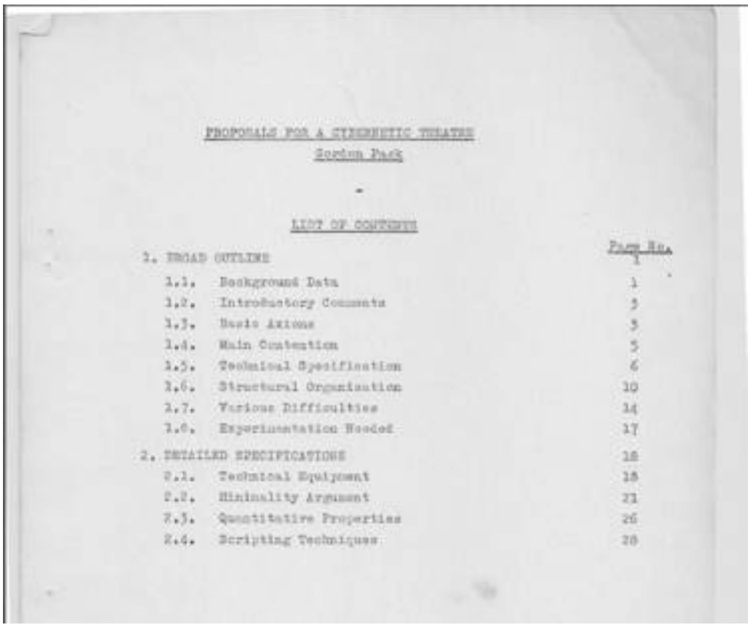
> This question once baffled me, but the cyberneticians … had a different answer. (Pickering, 2010, p. 6)

Ashby (1948) appears to take a similar theoretical position, suggesting that the idea of ‘action’ is detrimental to the representation of the brain as propagated by AI:

> To some, the critical test of whether a machine is or is not a ‘brain’ would be whether it can or cannot ‘think’. But to the biologist the brain is not a thinking machine, it is an acting machine; it gets information and then it does something about it. (Ashby, 1948, p. 379)

The ontology of cybernetics establishes a vision of the world as a significant place for the emergence of performativity and interaction.

The cybernetic theatre



PROPOSALS FOR A CYBERNETIC THEATRE
Gordon Pask

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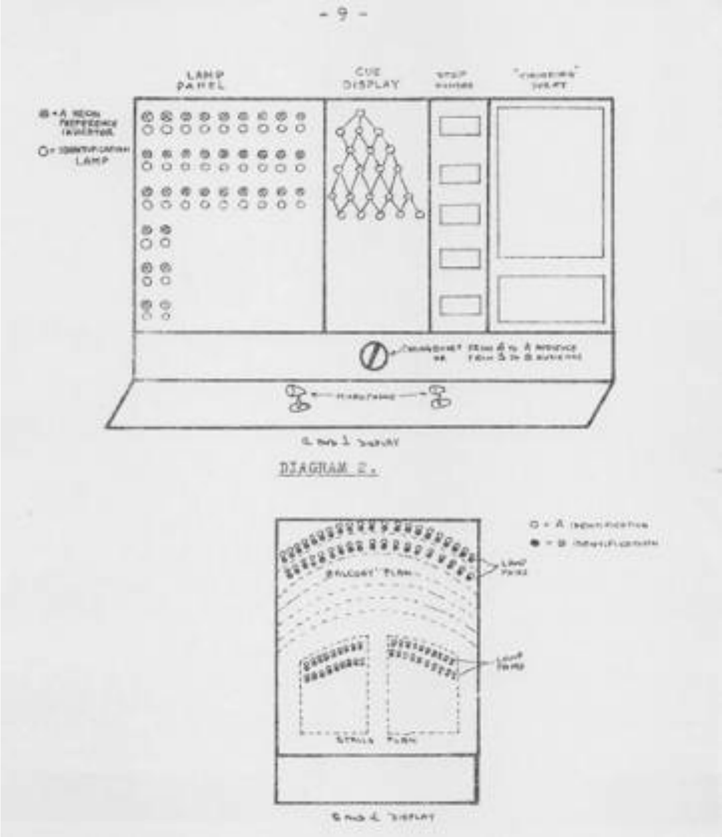

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Fig. 18 Gordon Pask’s ‘Proposal for a Cybernetic Theatre’, 1964

The cybernetic theatre represents a significant example of human interactive and performative engagement with the world. In 1964, Gordon Pask wrote and designed his ‘Proposal for a Cybernetic Theatre’, an unpublished manuscript for a workshop, where audience and actors could interact via feedback loops for specific performances. His initial idea was to include the possibility of giving the plot an open structure, whereby the audience could redefine the trajectories of the piece by using alternatives routes, even though some of the structural elements of the play would remain unaltered. The ‘Pask’s Cybernetic theatre’ is a significant example of an early view of an interactive media experience based on a cybernetic model. As Pickering explains (2010, p. 358), the thirty-page document written by Pask on behalf of Theatre Workshop and System Research describes in considerable detail how audience and actors could be coupled together via feedback loops in order to cooperate in determining the substance of a specific performance. According to Pickering, in his description of the cybernetic theatre proposed by Gordon Pask:

> During the performance, members of the audience could signal their identification with one or another of the principal actors. At specified branch points, the audience could also use levers to advocate different choices of action for their chosen character, drawing upon both their understanding of how the play had developed thus far and also upon ‘metainformation’ on their character’s thinking at this point, developed in rehearsal and provided in real time by ‘interpreters’ via headphones or earpieces. The interpreters in turn would then use hand signals, or perhaps radio, to let the actors know their supporter’s inclinations, and the play would proceed accordingly. Depending on how the play developed from these branch points, the audience was free to change identifications with actors, to make further plot decisions, and so on. (Pickering, 2010, p. 358)

In this sense, Pask’s contributions were unparalleled. He took part in the ‘Cybernetic Serendipity’ exhibition in 1968, and his research focusing on a ‘synesthetic colour music machine’ in the early 1950s is a legitimate contribution to cybernetic ontology, but it his plans for a cybernetic theatre that align best with the context of this research. According to Pickering (2010), Pask’s basic idea represented a new kind of theatrical performance, which would retain certain set-piece structural elements, specified in advance, but also include alternative routes for plot development between the set pieces in an ‘entailment-mesh-like structure’, including the possibility that the trajectories of the actors might redefine the significance of the fixed elements.

The tortoise ontology

Grey Walter is considered to be one of the pioneers of cybernetics, and his most significant contribution to cybernetics came with the construction of his ‘tortoise robots’. Pickering (2010) explores the contribution to science of the conception of the performative brain, using as an example Walter’s ‘tortoise machines’. Pickering (2010, p. 39) reads Walter’s work as thematizing a performative vision of ourselves and the world, and discusses the ‘tortoise’ from the point of view of ‘ontological theatre’, and then explores the social basis of his work. Walter was interested in strange performances and altered states, and the technologies of the self that elicit them, including flickering and feedback.

According to Pickering’s description, the ‘tortoises’ (or ‘turtles’) were small electromechanical robots, which Walter also referred to as members of a new inorganic species, ‘*machina speculatrix*’.

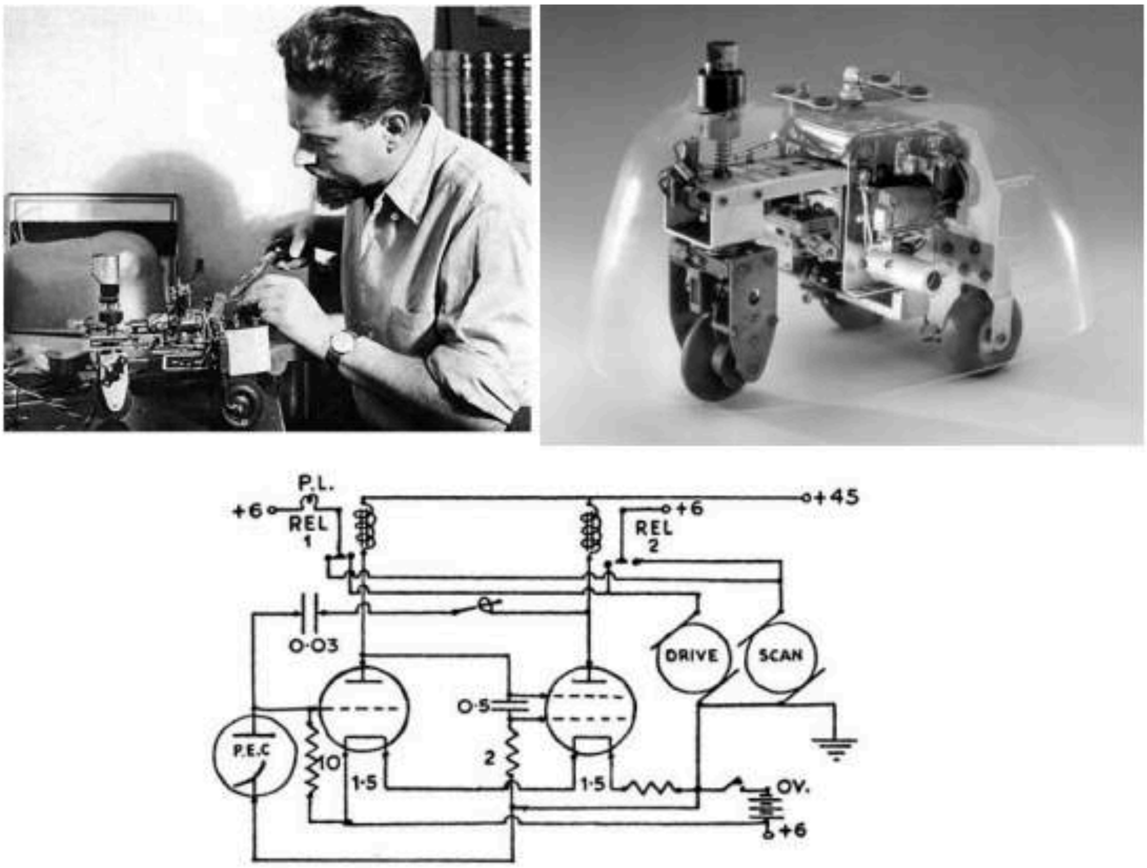

Fig. 19 Top left: Grey Walter (photograph by Hans Moravec); top right: Walter's '*machina speculatrix*' (National Museum of American History, Smithsonian Institute); bottom: the circuit diagram (Walter, W.G. (1954) *The Living Brain*. London: Duckworth & Co., p. 200.).

In his description of the technicalities of the tortoises, Pickering (2010, p. 43) describes how Walter gave them the names, Elsie and Elmer, and he relates Walter's notes on their behavior. They were battery-powered machines with two back wheels and a front axis that allowed what Pickering describes as a "cycloidal wandering". They also had sensors so that if they hit objects they could shuffle about to reposition themselves and move away. Their front axes had light sensors and the tortoises would move towards a torch beam, but as the sensors responded to light intensity, when they reached the source of the beam they would turn away. These kinds of movements made the 'creatures' appear as if they were making decisions;

Pickering describes their “perpetual wanderings up to and away from lights”. In addition, Walter programmed the machines to return to their hutches when their batteries began to die, so they could recharge. Pickering then goes on to describe the things the tortoises did that they had not been programmed to do and were more unexpected. They were fitted with lights themselves, and if they went past mirrors, they would respond to the reflection of their own light, or seemingly to their own reflection, with a kind of ‘mirror dance’, which Walter (1953, pp. 128-9) describes as “flickering, twittering and jigging”. But they would also be attracted to each others’ lights, which seemed like the performance of a mating dance. Walter wrote, “the machines cannot escape one another; but nor can they ever consummate their ‘desire’ ”.

Walter’s experiment was a clear example of the performative perspective of the brain as an ‘acting machine’ rather than a ‘thinking machine’; the tortoise was the first instantiation of the experiment. Note that the tortoise did not construct or process representations of its environment, bringing the notion of the performative brain down to earth. Of course, according to Pickering (2010, p. 49), Walter’s cybernetics had a hybrid character: it was non-modern in its thematization of the world as a performative black box, but modern in its representational approach to the inner workings of the brain. Clearly, in this chapter, our focus is on the unfamiliar ontology of cybernetics in the non-modern face of this hybrid, which works in opposition to (but also in a complementary way with) the modern. The tortoise ontology reveals our desire to understand aspects of cognition that have not yet been elucidated, even after years of reflection by scholars and interested researchers.

According to Pickering:

> [Cybernetic devices] explicitly aimed to be sensitive and responsive to changes in the world around them, and this endowed them with a

> disconcerting, quasi-magical, disturbingly lifelike quality. Wiener himself was well aware of this, and his writings are dotted with references to the Sorcerer's Apprentice (who casts a magical spell that sets matter in motion and cannot be undone) and the Golem of Prague (magically animated clay). Walter, likewise, spoke of "the totems of primitive man" and invoked the figure of Frankenstein's monster (1953, 113, 115). This sense of mystery and transgression has always attached to cybernetics. (Pickering, 2010, p. 7)

The tortoise ontology highlights the parallels between the performative and representational, the cybernetic model and the model of artificial intelligence, the mental models of HCI and the performative nature of the mind when it comes to embodied cognition and enaction. But it also elaborates an even more important aspect: the unpredictable nature of the organism as opposed to the disembodied, representational, disembedded mental model of HCI (discussed in depth in Chapter One) that apparently believes that human behavior is predictable.

According to Pickering:

> The tortoises were very simple and comprehensible artifacts. Anyone could understand how their two-neuron brains worked – at least anyone familiar with the relay and triode circuit of the time. But, as Walter argued, "the variations of behaviour patterns exhibited even with such economy of structure are complex and unpredictable" (1953: 126). (Pickering, 2010, p. 50)

He continues:

> [C]ybernetics stages for us a vision not of a world characterized by graspable causes, but rather of one in which reality is always "in the making" to borrow a phrase from Willian James. We could say, then, that the ontology of cybernetics was nonmodern in two ways: in its refusal of a dualist split between people and things, and in an evolutionary, rather than causal and calculable, grasp of temporal process. (Pickering, 2010, pp. 18-19)

For cyberneticians, even simple organisms and structures appear to exhibit very complex behavior when they combine with the environment, delivering actions in an unpredictable fashion.

Cybernetics therefore helps us think more deeply about the nature of practice and performance. In Pickering's (2010, p. 381) terms, it is about human and non-human systems, or both together, which "staged their own performative dance of agency, that fore-grounded performance rather than treating it as some forgettable background to knowledge, and it is through this primary sense in which one can read cybernetics as ontological theatre – forcing us [to remember] the practical domain of performance and bringing that to the fore". For Pickering, performances are not about knowledge, but when knowledge comes into the picture, it is also part of the performance.

Pickering (2010, p. 51) describes "the tortoise as ontological theatre – as variously conjuring up and playing out an ontological vision of performance and unknowability". He goes on to say:

> The tortoise thus again appears as ontological theatre, but in a different sense from that discussed above. As a piece of engineering, it displayed the fact that a reductive knowledge of components does not necessarily translate into a predictive understanding of aggregate performance. (Pickering, 2010, p. 50)

Another perspective is included here to support the explanation of how cybernetics is performative, but also to show that the concepts of embodied cognition, external mind, or distributed cognition cannot be seen as disconnected from the ideas proposed by cybernetics.[37] Bateson's (1972, p. 229) ideas of cybernetics resemble the idea of how the mind, world and the organism cannot be seen cognitively as separate entities: for example, he explains that "[o]ur knowledge of what sort of thing the environment *is*, what sort of thing an organism *is*, and, especially, what sort of thing a mind *is*" is only partial. Notice that, like the tortoise ontology, the epistemology of cybernetics Bateson proposes is fundamentally a cybernetic discussion around the environment, the limits of the 'self' and its engagement with materiality:

> Consider a man felling a tree with an axe. Each stroke of the axe is modified or corrected according to the shape of the cut face of the tree left by the previous stoke. This self-corrective (i.e. mental) process is brought about by a total system, tree-eyes-brain-muscles-axe-stroke-tree; and it is this total system that has the characteristics of immanent mind. … [T]his is not how the average Occidental sees the event sequence of tree-felling. He says, "I cut down the tree" and he even believes that there is a delimited agent, the "self", which performed a delimited 'purposive' action upon a delimited object. (Bateson, 1972, p. 230)

It is reasonable enough to suggest, therefore, that when someone manipulates a puppet or a ventriloquist's dummy, they are, to some degree, also being manipulated by the puppet or dummy. Moreover, how much influence does the audience (as agents) hold? This raises a range of significant questions, such as the limits of human and non-human agency, and the limits of agentive entities.[38] It also articulates the importance of objects for daily, lived

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[37] According to Winograd and Flores (1986), in their book *Understanding Computers and Cognition*, Varela was very much influenced by cybernetic ideas.

[38] There have been some studies into whether non-physical social entities (such as states or corporations) are agentive entities. According to one theory, even though such entities cannot directly act in physical ways, they should nevertheless be considered agentive entities because of their ability to act though representative physical agents (see Robinson, E.H. (2011) 'A Theory of Social Agentivity and its Integration into the Descriptive Ontology for Linguistic and Cognitive Engineering'. *International Journal on Semantic Web and Information Systems,* 2011 7(4): pp. 62–86.)

experience and cognition, illustrating the similarities between the central idea of embodied cognition and cybernetics, which also operates by taking into account environmental constraints. Bateson's example of the blind man with the stick became a classic example of an explanation of the limits of the 'self' (or mind), the importance of the environment, and our relationship with everyday objects and artefacts:

> If you ask anybody about the localization and boundaries of the self, these confusions are immediately displayed. Or consider a blind man with a stick. Where does the blind man's self begin? At the tip of the stick? At the handle of the stick? Or at some point halfway up the stick? These questions are nonsense, because the stick is a pathway along which differences are transmitted under transformation, so that to draw a delimiting line across this pathway is to cut off a part of the systematic circuit which determines the blind man's locomotion. (Bateson, 1972, p. 318)

Pickering's 'performative brain' is described in Bateson's case as the 'performative self'. According to Pickering (2010, p. 183), Bateson was at the heart of the idea of the performative brain as the medium of exchange, although it is "better described in Bateson's case as the performative self – a nonmodern self capable of strange performances and the achievement of altered states, including a pathological disintegration into madness in one direction, and dissolution into nirvana in the other".

Puppets and ventriloquism: articulating degrees of agency

In simple terms, puppetry is nothing more than a form of theatrical performance where the actor is represented by a puppet or an articulated doll, an inanimate object manipulated by a performer. Beaumont (1958, p. 7) argues that historical evidence suggests that the first puppet is as old as civilization itself. Terracotta dolls with articulated limbs, and similar figures with iron control-rods projecting vertically from their heads, have been discovered, and are part of a Sicilian puppet tradition. He also points to numerous references in the work of classical writers such as Aristotle, Horace, Plato and Xenophon, among others, citing figures that were made to perform through pulling strings attached to them.

The more contemporary version of puppetry was born in Italy. The art was introduced to Europe through travelling shows, in which the performances were adapted to accommodate cultural differences and local particularities to please the audience. Batchelder and Comer (1959, p. 11) describe puppetry as an all-embracing art form, in terms of its possibilities, which provides, in their words, “stimulation for people who have an inquiring and flexible mind”. Puppetry is therefore a universal form of entertainment. Nearly every country has some kind of puppet theatre, in many places so ancient that its origins are unknown. Enough is known, however, to suggest that puppets have a long and honourable history. In some countries they appeared earlier and lasted longer than in others. It is known that shadow puppets existed in Java in the 10th century; they influenced the development of theatre (with human actors), and are still an important part of popular theatre. Shadow puppets were developed even earlier in China, reaching their heyday in the 18th century, and continue to maintain a place in the folk art of the country. Batchelder and Comer (1959, p. 11) demonstrate that in Western Europe puppets were probably first associated with religious ritual, even as far back as Greek times.

Ventriloquist dummies and puppets are types of media that deliver an experience, which can be programmable, modelled by the audience and the ventriloquist, but is also responsive, distributed, contingent, contextual and self-regulated. They are theatrical and performative artefacts or figures under human ‘control’. They are not very different from automatons in some respects, but of course automatons are more like mechanical machines, programmed to perform activities, whereas theatrical art delivers a more ‘in-time’ experience. Both forms of expressive art, however, display an intrinsic rhetoric that, in the final instance, reveals an intense relationship between human and non-human through their shared actions, rejecting the idea of a dualism between humans and objects. It is not surprising that puppetry, automatons and ventriloquism are seen as springing from the same root: the human desire to materialize the fascinating idea that human agency can be embodied in objects, which are themselves human creations.

The first known use of ventriloquism dates back to 1584. Originally, ventriloquism was a religious practice, and the name comes from a Latin expression meaning ‘to speak from the stomach’; the Greeks also called this form of art, ‘gastromancy’. The noises produced by the stomach were thought to be the voices of the ‘unliving’, who had taken up residence in the stomach of the ventriloquist. The ventriloquist would then interpret the sounds, as they were thought to be able to speak to the dead, as well as foretell the future: most people saw the practice of interpreting sounds made by the human body after death as completely natural. In the Middle Ages, ventriloquism was thought to be synonymous with witchcraft, but over time, as spiritualism led to stage magic and escapology, ventriloquism became more of a performing art. By the 19th century its mystical roots had become part of the past, and it has since turned into the freakish dummy show that amuses audiences today. However, although the film *Magic* (1978) used ventriloquism as an allegory, it also put a check on human authority, questioning who is actually in control and the level of influence *things* have over human life. Ventriloquism is a theatrical art that cannot simply be reduced to a man manipulating a wooden doll.

Satz and Wood (2009) illustrate why the allegory of puppetry and ventriloquism is so important for the argument in this thesis. The art of puppetry is not a privileged or hierarchical relationship between human and non-human; instead, the authors contend that agency is symbiotic, symmetric and distributed between the actors; they systematically deny the existence of any form of dualism. Ventriloquism and puppetry are theatrical arts in which the non-human speaks and acts by being ‘spoken through’:

> The puppet is implicitly ventriloquial. It speaks by being spoken through, it is a mouthpiece of sorts through which another voice can reverberate. The puppet moves by being moved through, as the gestures of the puppeteer trickle down and expand through its articulated body. The repeated occurrence of the word ‘through’, the puppet’s favoured preposition, indicates that it is a projected, mediated, ventriloquised object, one through which the characteristics commonly associated with subject-hood [are manifested]. (Satz and Wood, 2009, p. 01)

It is no exaggeration to say that several scholars and philosophers in various disciplines are developing explanations that share similar understandings of the same phenomenon. Suchman (1987), for instance, argues that human action is constantly constructed out of dynamic interaction with the material and social worlds, and his views have contributed an intellectual current to the field of HCI. Meanwhile, it is the point of view of Hutchins (1995) that, in cognitive aspects, human knowledge is not only confined to the individual: he suggests that the development of knowledge can be attributed to a system of thinking agents interacting dynamically with artefacts. However, it is Malafouris (2010, pp. 01) who goes furthest with the idea of material engagement, developing the theory of the extended mind, in which, in his words, he explores the “diachronic influence and transformative potential of things in human life”.

Malafouris and Renfrew (2010) paraphrase the pre-Socratic Greek philosopher Thales of Miletus, in the title to their introduction, using the term “the cognitive life of things” for Thales’ expression, “things full of gods”. Of course, Malafouris is not claiming that inanimate objects have any sort of divinity or are alive in some sense; rather, he is suggesting that things and material objects make up our everyday world of thought and action:

> Since the early years of our childhood we constantly think *through* things, actively engaging our surrounding material environment, but we very rarely become explicitly aware of the active potential of this engagement in the shaping of our minds and brains. (Malafouris and Renfrew, 2010, p. 1)

Malafouris seems to agree with the ideas of Latour (1994, 1999), who critically rejects any form of ontological dualism that opposes the human and the non-human. According to McMaster and Wastell (2005):

> Bruno Latour argues that the modern world is so pervasively fabricated, that tools and technologies are so ubiquitous, that we cannot meaningfully separate the human from the non-human … [T]he human and the non-human are, for Latour, symbiotically related: neither can exist without the other. (McMaster and Wastell, 2005, p. 177)

This is Latour’s ‘principle of symmetry’: the place where a person and a tool exist independently of each other is a distinction made purely for convenience sake, and is not a functional one. The symbiosis is mutually critical – neither can literally exist without the other. Latour highlights the performative nature of humans and objects through action, as McMaster and Wastell show:

> Given this characterisation, arising from a rejection of both dualism and essentialism, humans and non-humans are inextricably enmeshed in ever more complex networks of associations. Latour calls these associative networks sociotechnical collectives. Only collectives can act. (McMaster and Wastell, 2005, p. 76)

They continue:

> Human lives are so bound up with artefacts that even so apparently simple an action as putting on our clothes produces a complex collective, a hybrid actor. The repertoire of the clothed man or woman is extended and enacted through the collective that includes his or her clothes, mobile phone, laptop computer, car, and so on, as well as his or her body itself. Responsibility for action, in this depiction, is shared among the various actants, as competence and responsibility are the properties of sociotechnical composites. (McMaster and Wastell, 2005, p. 178)

According to McMaster and Wastell, Latour understands that existence is a matter of action:

> All actants (actors, actions and enactings) have a history, and it is only through their action in the world that they have an identity. All actants are changed as they combine and associate with other elements of an evolving and ever-more-ramifying network of actants. (McMaster and Wastell, 2005, p.178)

For McMaster and Wastell (2005), one of the most well-known examples developed by Latour is his explanation that uses a gun as a technological exemplar. His fundamental question is: “Do guns kill people or do people kill people?” The answer is quite elaborate, because Latour shows it can be answered from the perspective dualist philosophy, which offers an immutable distinction between subjective and objective world-views in relation to agency and technology. In this dualistic worldview, the relation between human and non-human is crystallized; it is instrumental: agency is an exclusive prerogative of humans, technology is merely the instrument. McMaster and Wastell's interpretation of Latour is very appropriate for this discussion. As they explain:

> For Latour, existence is a matter of action. There is no room for essences in his system, i.e., a priori ahistorical properties that capture the intrinsic nature of a phenomenon or entity (be it human or non-human). All actants have a history, and it is only through their action in the world that they have an identity. (McMaster and Wastell, 2005, p. 178)

McMaster and Wastell (2005) explain that in the principle of symmetry, proposed by Latour, the term 'actant' is emblematic and applies not only to humans but also to non-human entities. For Latour, both humans and non-humans act and do things, and are symmetrical in this sense. They are at the same level, equal, within a network of complex associations. Maintaining the subject-object dichotomy prevents our full understanding of such 'sociotechnical collectives', of even recognizing their existence and the fundamental part they play. "It is neither people nor guns that kill. Responsibility for action must be shared amongst the various actants" (*Ibid.,* p. 180). According to McMaster and Wastell (2005, p.177), for Latour, "[i]n the dualist worldview, the relationship of the human to the non-human is purely an instrumental one; agency is the exclusive prerogative of humans, and technology is merely an instrument".[39]

Dreyfus (1972, p. 266), inspired by Heidegger's *Being and Time*, speaks of 'meaningful objects': "[T]he meaningful objects ... among which we live are not a model of the world stored in our mind or brain; they are the world itself." As for AI, according to Dreyfus (1972,

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[39] Latour (1994, 1999) systematically refutes this dualistic idea, treating objects as part of a sociotechnical network, and giving equal treatment to human and non-human actors. To find out more, see actor-network theory.

300), “[i]t turned out to be very difficult to reproduce in an internal representation for a computer the necessary richness of environment that would give rise to interesting behavior by a highly adaptive robot”, and he concludes that “this problem is avoided by human beings because their model of the world is the world itself”.

The cognitive importance of agents coupled with the environment and material objects is a subject that is frequently discussed within the field of artificial intelligence – it is what AI theorists define as ‘the frame problem’.[40] Agre transposes the subject to the arena of technology:

> I believe that people are intimately involved in the world around them and that the epistemological isolation that Descartes took for granted is untenable. This position has been argued at great length by philosophers such as Heidegger and Merleau-Ponty; I wish to argue it technologically. (Agre, 1997, p. 243)

According to Dreyfus (2007, p. 252), Merleau-Ponty’s work, on the contrary, offers a nonrepresentational account of the way the body and the world are coupled that suggests a way of avoiding the frame problem”. Dreyfus explains Merleau-Ponty’s position thus:

> [A]s an agent acquires skills, those skills are ‘stored’, not as representations in the agent’s mind, but as the solicitations of situations in the world. What the learner acquires through experience

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[40] According to the Stanford Encyclopedia of Philosophy, to most AI researchers, the ‘frame problem’ is the challenge of representing the effects of action in logic without having to represent explicitly a large number of intuitively obvious non-effects. But to many philosophers, the AI researchers’ ‘frame problem’ is suggestive of wider epistemological issues. Is it possible, in principle, to limit the scope of the reasoning required to derive the consequences of an action? And, more generally, how do we account for our apparent ability to make decisions on the basis only of what is relevant to an ongoing situation without having explicitly to consider all that is not relevant? See Shanahan, M. (2009) ‘The Frame Problem’ in Edward N. Zalta (ed.) *The Stanford Encyclopedia of Philosophy*, Winter 2009. Accessed online at: <http://plato.stanford.edu/archives/win2009/entries/frame-problem/>.

> is not represented at all but is presented to the learner as more and more finely discriminated situations. If the situation does not clearly solicit a single response or if the response does not produce a satisfactory result, the learner is led to further refine his discriminations, which, in turn, solicit ever more refined responses. (Dreyfus, 2007, p. 252)

Bateson with his ‘felling a tree with an axe’ and ‘blind man with a stick’ examples, Latour with his question of ‘do guns kills people?’, and finally Heidegger with his ‘hammer’ theory construct a parallel way of thinking about how we really perform with objects, tools and artefacts at many different levels, which turns into a discussion about agency and the limits of the self. According to Clark:

> Heidegger (1927) wrote of the importance of ‘Dasein’ (being there) – a mode of being-in-the-world in which we are not detached, passive observers but active participants – and stressed the way our practical dealings with the world (hammering nails, opening doors, and so on) do not involve detached representings (e.g. of the hammer as a rigid object of a certain weight and shape) so much as *functional couplings*. We use the hammer to drive in the nail, and it is this kind of skilled practical engagement with the world that is, for Heidegger, at the heart of all thought and intentionality. A key notion in this analysis is the idea of equipment – the stuff that surrounds us and figures in the multiple skilled activities underlying our everyday abilities to cope and succeed. (Clark, 1997, p. 171)

Latour (1994), however, disagrees with Heidegger. For Heidegger, man is possessed by technology, while Latour’s principle of symmetry refuses the idea that human and non-human are asymmetric in terms of agency:

> For Heidegger, a technology is never an instrument, a mere tool. Does that mean that technologies mediate action? No, because we have ourselves become instruments for no other end than instrumentality itself. Man – no woman in Heidegger – is possessed by technology,

> and it is a complete illusion to believe that we can master it. We are, on the contrary, framed by this *Gestell*, which is in itself one way in which Being is unveiled… Is technology inferior to science and pure knowledge? No, because, for Heidegger, far from serving as applied science, technology dominates all, even the purely theoretical sciences. By rationalising and stockpiling nature, science plays into the hands of technology, whose sole end is to rationalise and stockpile nature without end. Our modern destiny – technology – appears to Heidegger radically different from *poesis*, the kind of 'making' that ancient craftsmen knew how to obtain. Technology is entirely unique, insuperable, omnipresent, superior, a monster born in our midst. But Heidegger is mistaken. I will try to show how and in what way he is wrong about technical mediation by using a simple, well-known example. (Latour, 1994, p. 30)

But Latour seems to agree with Heidegger in one point, as all three approaches (Bateson, Heidegger and Latour) implicitly accept Heidegger's critique of Cartesian internalist representations, and suggest that cognition is embedded and embodied. The embodiment approach, instead of postulating an isolated and detached mind, understands thought as the result of embodied activities, as an interaction of brain, bodily movements and the world itself. It rejects the implication of an internal representation imposed between immediate perception and its reflection. This is one of the fundamental things that performative art, such as ventriloquism and puppetry, helps elucidate. Both reflect an opposition to the dualist world-view in the understanding of any form of interaction (and according to the findings of this research, HCI too should be understood in a non-dualistic way). Any sort of equation that privileges either humans or computers (of some sort), failing to see that such a hierarchy is non-existent, will fatally incur a reductive analysis. In these terms, it is the interaction between things that is important and that needs to be given priority.

Thus, the contrast between theories of artificial intelligence and cybernetics is not just a matter of semantics, but is clearly substantial. As Pangaro (2006) points out, AI differs from cybernetics in its epistemology, in how reality is understood, and also in terms of memory and representation. It can be concluded that the discussion in this chapter has revolved around the limits of human beings' cognitive boundaries, the idea of the mind as performing and acting with the environment, and the importance of objects and artefacts in our daily lives.

Concluding Remarks

The research presented here uses transdisciplinary methods to suggest ways of improving human interaction with computers. It proposes a careful revision of what is considered to be fundamental to how we understand our interaction with computers, starting with the problem of the mental model approach, and revisiting the topic through disciplines such as AI, cybernetics, cognitive science, performance arts and philosophy, among others. The research shows that the mental model has been remarkably resilient in HCI. However, it may be resilient, but it is a model of the mind that has its roots in a rationalist tradition, and as such, fundamentally neglects human beings' embodied and embedded relationship with the environment. Such a model, based on representation, ignores the centrality of artefacts, machines and the ecology of objects, as well as the importance of explaining human cognition and intelligence in terms of life experience and external constraints.

This model of the mind perpetuated by the mental model theory is an inheritance that has contaminated the field of HCI. It has been shown to be a limited view of how people understand things and concepts, a misinterpretation, and as such it is very problematic. It has been insufficient to understand or explicate human action and the development of human beings' ability to interact with computers; its explanation of interaction is based solely on human beings' own cognitive competencies and their cognitive capacity to understand and operate computers and machines, rather than the more insightful interpretation of human cognition essential for designers and programmers who develop interactive systems. This thesis has argued that the HCI community lacks a more contemporary understanding of human cognition, and therefore is denied all the possibilities that embodied cognition can unfold. The field of AI, for example, realized that it could not go further without recognizing that this notion of intelligence was misguided. Thus, a completely new interpretation of intelligence in the field of AI determined the re-establishment of the entire discipline. HCI could benefit from just such a new interpretation of the old, rationalist model of mind that has been erroneously used for years.

The inspiring ideas of Turing in the 1950s were considered a landmark, inaugurating the field of AI, and they were both influential in and also symptomatic of its development. However, they helped perpetuate a disembodied model of cognition and intelligence that, historically, has proved difficult to displace. Turing’s ideas, based on symbolic manipulation and computation, although groundbreaking and provocative at the time, do not embrace the complexity of human mental phenomena and have proved unsatisfactory in terms of sustaining research into artificial intelligence. Searle’s Chinese room experiment exposed the main fragilities in the Turing test and the limits of computer symbol manipulation as a model of the mind. The experiment persuasively illustrated that computers could process symbols but could not attach meaning to or understand the symbols they processed. However, the Chinese room experiment also demonstrated that the mental model theory, although it may appear to explain intelligence, is disconnected from the world, in the same way as the instruction book inside the cabinet, which provides a purely mechanical way of interpreting Chinese words. Mental models do not explain intelligence and cognition in terms of how it is contextualized by experience of the world.

These fragilities made it even more evident that the mind is a dynamic entity, affected by changes and contingencies, an entity that alters over time. They also demonstrated that intelligence cannot be explained by computation alone. The lack of contextualization in which to understand human intelligence is a problem shared by AI and the mental model in HCI. But a reconceptualization of cognition and intelligence makes it possible to propose a reconciliation. This thesis, by discovering the parallels and allegorical links between the

Turing test, the Chinese room experiment, and the mystery of automatons (exemplified by the Turk chess-playing machine) promotes such a reconciliation. The allegory of puppetry and ventriloquism further amplifies the reconceptualization of cognition in the use of eloquent objects. The limits of the mental model and symbolic AI is evident when cognition is explained in terms of embodiment. It is through the embodied perspective that mind, body and world are reconciled, because, according to the embodied perspective, cognition evolves and is driven by action; it is not an abstract mental phenomenon that happens only in the human head as it is through both our minds and our bodies that we understand and interact with the world.

The reconceptualization of the human mind obviously entails new consequences, especially in terms of how we relate to the world and machines, computers and artefacts. Avoiding a more radical view of externalism, this thesis advocates a theory of the human capacity for extended cognition. It reconciles computation with embodied cognitive experiences, and also brings language and metaphor into the discussion, suggesting that language is also an artefact through which we amplify our cognitive and computational capacities. It reinstates metaphor not as a rhetorical strategy or linguistic embellishment, but as a part of the conceptual system that is pervasive in everyday humans life. Language and cognitive metaphors can help reveal the meaning of concepts, schema and visual metaphors, and deserve greater appreciation.

Another important topic that is discussed by this research is humanity’s imaginative desire to create artificial life and intelligence, and the way this ambitious idea suddenly turned to dust, like the dust that the Golem of Jewish folklore is made of. The early hopes and false notion that human intelligence could be replicated in hardly any time at all, was dramatically replaced by a realization of the inherent difficulties, which have never been overcome and still persist to this day. As a result, the discipline of AI fell into rapid decay, until the conceptualization of intelligence could be reinterpreted. However, the concept of intelligence began to be interrogated anew: intelligence was no longer regarded as a purely human property, but one that could be attributed equally to a human being, an animal or even a material entity. AI also embraced the idea that a human-centric intelligence could no longer be achieved outside a body; to manifest a human form of intelligence, the artificial agent needed a body. Thus, intelligence became embodied, situated and contextualized. Intelligence was no longer a property of the agent itself – either human or non-human – but became something that happens ‘in between’, that emerges as result of interaction. Overall, this suggests that intelligence *is* interaction. This condition is subtly revealed in the contrast between AI and cybernetics.

Intelligence can be manifested in many forms: by acting, thinking through objects, in objects. Cybernetics emphasizes machines that act to the detriment of machines that think, but cognition is driven by action, and they cannot be understood separately. On the one hand, AI, as a discipline, tried to form a representation of the external world and human experience, and to formalize it in order to create an autonomous, thinking, sentient being. On the other hand, cybernetics is the discipline of performative adaptation with the environment through feedback loops – the world as it comes. This contrast is represented by the Turk chess player and ventriloquism. It seems to have peculiar dimensions in which the performative nature of cybernetic automatons is valued rather than repressed, bringing cybernetics and its performative nature into the explanation or enjoyment of the mystery of automatons.

Cybernetics appears tangential to the rationalist tradition; it seems to embrace the non-rational dimensions of the ways that machines perform and are interpreted. It is this performative dimension that HCI has negated, or at least failed to embrace; however, if it is factored in, then a fuller understanding of interaction is possible. Cybernetics reveals a far richer picture of the many dimensions of interaction, intelligence and the performance of and with machines that take place during human beings' interactions with computers. Interaction is not an independent function from which intelligence emerges. HCI and interaction design assume that interaction means building interfaces that can be conceptually slotted in-between the user and the machine. The methods of HCI therefore prevent designers from working with a more enriched view of intelligence (as embodied, enactive, situated and distributed).

HCI's reliance on what has been shown to be a traditional rationalist legacy prevents it opening up to multiple ways of understanding intelligence, interaction and adaptation, because it misunderstands concepts that are fundamental to what make us human: that is, a conjunction of mind, body and world where one cannot exist without the other two. The assumption is that the interface stops the user having to know about the machine behind it, and as such, it forms a separation barrier between human and machine. But when humans use computers they are doing much more than interpreting interfaces. Intelligence penetrates the barrier as it works environmentally and is not contained in the brain but evolves with the things we interact with. From this perspective, which includes the use of inanimate things such the ventriloquist dummy, it is clear that human beings are far more intelligent than the disciplines of interaction design and HCI, in their desire to generalize and patronize, give us credit for.

The organization of computer design prevents an enriched understanding of intelligence and interaction from being considered because programmers are separated from designers and users by the mental assumptions that HCI propagates. This research, however, has not focused on these kinds of practicalities; rather, it has focused on the models of intelligence used in computer design, AI and cybernetics, which it has analyzed in relation to ideas concerning intelligence and cognition in cognitive science, where there is little common ground. It seems that HCI is stuck in the old models of cognitive science. But cognitive science has moved on, and HCI and interaction design have not taken on board this new thinking about thinking; they are stuck in the old paradigm. This research has traced HCI’s dependence on and links to cognitive science, and has demonstrated how other ways of thinking about interaction (cybernetics, with the example of ventriloquism) has been sidelined and cannot be accommodated in the traditional HCI view of interaction.

Transdiciplinarity as a method

As in all research that tries to be bold enough to engage with transdisciplinarity, it is easy to recognize the advantages of crossing disciplines in order to cover those aspects of research that appear to inhabit a gray area. However, trespassing across disciplinary boundaries to produce new knowledge can create uncertainties and a level of obscurity. In the case of this particular thesis, these uncertainties can be seen as a sort of side-effect of dealing not only with all the disciplines described above, but also of its subtle relationship with meta-cognition, with the self-reflective nature of models of the mind, and with disciplines that at first sight are not clearly connected. Hence, it does not possess an immediate transparency, but rather it presents a work of a more reflective nature.

Transdisciplinarity and its uncertainties

At first glance, the argument this thesis has expounded can be interpreted as lacking a traditional or orthodox scientific method. Transdisciplinarity can be insightful, but also abstract and sometimes uncanny. It creates uncertainties and the feeling that what has been said is not grounded in the certain terrain of one particular discipline. But, by establishing a more exploratory and cross-referenced research method, integrating knowledge from heterogeneous sources (cf. Pohl and Hirsch Hadorn, 2006), it addresses problems that must be faced using the knowledge that comes from different frameworks and perspectives in a simultaneous fashion.

According to Pohl *et al*. (2008, p. 414), “[a] starting point for transdisciplinary research is given when knowledge about a socially relevant problem field is uncertain, when the concrete nature of a problem is disputed, and when there is a great deal at stake for those concerned by a problem and involved in investigating it”. The challenge of this research has been to engage in a discussion that can be applied to what could be considered a specific ‘real life’ problem, but the nature of the discussion proposed in the research itself demands a philosophical approach, used in a very speculative way; it requires an approach that can be refined in such a way that it can embed specific problems relating to the way human beings interact with machines and the development of human computer interaction, but without making any pact with the practical application design interaction or interfaces.

The challenge of this thesis, therefore, has been to try to apply a more humanistic perspective, one that could provide a useful framework, offering insights and generating discussion in several areas of knowledge where the computational model of the mind still persists, breaking a long tradition of how the human mind is understood inside HCI and the computer sciences. Its focus is on the human rather than the computer. The phrase ‘humanistic approach’ is used to imply that an understanding of the human mind as a whole cannot be reduced to only one model, as every person is unique in terms of the way they perceive and understand reality. Cognitive science is of course insufficient to validate the arguments presented here. For this reason, although the research has focused on aspects of the mind in cognitive terms, rather than cultural differences, it has also contemplated different disciplines that could contribute greater depth, such as philosophy (of the mind), history (of media archeology) and performance arts. Transdisciplinarity not only integrates across disciplines but includes a set of approaches that can generate new, comprehensive knowledge and an overarching synthesis (cf. Klein, 2007)This is what this thesis has aimed to do in its attempt to achieve new routes to understanding human beings' interaction with computers.

Addressing limitations

What follows are some final thoughts on the limitations of the thesis and some suggestions for further research that arise from the thesis.

This research analyzed the problem of how human beings interact with computers outside the narrow scope of operation provided by mental models. It proposed a discussion of different ways to understand the human mind, using aspects of several different disciplines, such as media archeology, philosophy of the mind, AI, cybernetics and performative practices, as a framework. Transdisciplinarity as a methodological approach in this research is transversal, and instead of giving guidelines or technical instructions, it presents an enriched view of interaction from a cross-disciplinary perspective, including the humanities. Although it does not provide guidelines, it is hoped that makers, designers, scientists and philosophers will all find something useful in it to reflect upon. The research purposefully does not touch directly on themes that are often discussed in the literature – for instance, the graphic interface. Interface constitutes just one element among several that need to be investigated. The focus is therefore on the mind and the body, exploring the contrast with machines. The topics are addressed in a more fundamentally philosophical and historical than technical way, and therefore the research does not provide any technical or design solutions, but it does touch on areas that chime with aspects of the mind that are shown to be misunderstood among the HCI community as a whole.

With a reasonable amount of experience as an educator teaching design and interactive media, I could tell that most of the HCI literature is not clear about the foundations of the theory they provide. It is pretty much founded on cognitive science, mainly cognitive psychology. Personally, I believe what is needed first is an understanding of the mind in general terms before this can be applied to understanding more specific things, and then to solving real problems in HCI. The field itself, it seems, suffers from the lack of a more philosophical, artistic and imaginative approach.

The part of the thesis that analyzes the development of AI might not satisfy the specialist in the field, who seeks immediate answers to pressing practical problems, but that is not the intention here. Instead, the intention is to create a framework and overview of the field, touching on aspects of symbolic AI and contrasting them with the intelligence that is built through our experience as embedded in the environment, which this thesis argues is central to an understanding of interaction.

Future developments

The results of the research undertaken in the Transtechnology Research group show evidence that new knowledge can be accessed by the use of transdisciplinary methodology. Such a method recognizes the existence of different levels of reality that cannot be accessed by a strict disciplinary approach. As a result, I would like to recommend some specific approaches that will be crucial for future research developments.

First, although the transdisciplinary approach delivers an enriched view of the subject of study, at the same time, it can be recognized that the approach promotes a level of subjectivity that is not appropriate for delivering practical methods and techniques in order to build and design better forms of interaction between humans, machines and computers. That said, one recommendation for future research is to attempt to translate the concepts demonstrated here into more practical terms. In other words, to discover how embodied cognition can be applied in terms of design-product development, where the theme of interaction is central.

The same aspect that appears fragile – as some concepts were not delivered literally enough to be translated into design methods and thus easily applied – also represents the strengths of a thesis that offers an imaginative approach, open to different interpretations in different arenas. However, in terms of future research, some themes that were not covered by the present thesis remain to be uncovered. For example, some aspects of performing and theatrical arts could be explored more deeply in terms of interaction. As Laurel remarks (in the Prologue to Chapter Five), there seems to be a strong connection between consciousness and theatrical performance, and these themes deserve a more careful analysis. The use of theatre as a medium for exploring human aspects of consciousness could not be entirely covered by this research, as for instance, in the cybernetic theatre mentioned in Chapter Five. Also, some aspects of ventriloquism and puppetry, such as feelings, meaning, language, metaphor, experience, aesthetics, reasoning and logic, remain untouched and might be interesting areas for future research. Different automatons and machines also provide a unique approach to understanding intelligence, interaction and the mind, and represent areas that would warrant further investigation.

Future research in graphic design, conducted using an embodied mind approach rather the representational one that has been predominant thus far, would also be of great benefit. Also, themes such as semiotics, logic, aesthetics and meaning, which could be understood in different ways, could provide a different foundation for how we understand language, metaphor, schema and mind.

HCI could also benefit greatly from further research, as the intervention of this research only applies to the mental model theory. Although at first glance this thesis may appear a timid intervention, the insights it provides fly in the face of years of a persistent and resilient model of the mind that is foundational to HCI. Future work could include practical ways of integrating the present ideas through joint publication, or particularly through an educational program at the university where I have undertaken this research: the teaching of design would clearly benefit from an educational approach that used more transdisciplinary methods and is more philosophically, artistically and historically informed.

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Appendix

Marcio Alves da Rocha (10321499)

Director of Studies: Prof. Dr. Michael Punt
Second Supervisor: Dr. Martha Blassnigg

Events attended

- Ars Eletronica Festival - Origin – How It All Begins – Linz – Austria – (01.09/06.09)
- CyberArts – Prix Ars Eletronica 2011 – PrixArs - Linz – Austria (01.09/06.09)
- Campus Exhibition – University of Tsukuba (JP) - Seriously Playful / Playfull Serious - (01.09/06.09)
- Interface Cultures – Unuselessness – The Useful useless - (01.09/06.09)
- Symmetries – A presentation of the work being done at CERN—the second exhibition having to do with this year's festival theme. A heterogeneous array of experimental assemblies, images and exhibits invites visitors to confront highly diverse manifestations of the human spirit of inquiry and the joy of discovery.
- Robotinity – The New Robolab / What machines dream of
- Sensing Place / Placing Sense – Symposium - Symposium und Ausstellung Im Rahmen des Ars Electronica Festivals 2011.

- International Network for Trans-disciplinary (post doctoral)
- Research (INTR) Conference in Budapest 2011 (18/02/11 to 19/02/11). www.mke.hu/node/31721
- Workshop International Workshop at Art & Science: synergy of technology and art in the city spaces. Erasmus Intensive Programme 2011. Gdansk – Poland (9- 22 October 2011). Tutoring experience with Erasmus students of Architecture

Seminars Attendance

Transtechnology Seminar series 2010/11

Reinstating the Visual: Aby Warburg's Mnemosyne Atlas
(http://trans-techresearch.net/research/seminars/1011-seminar-series)

- September. Business Meeting
- October 20, 2010. Michael Punt and Martha Blassnigg
- November 17, 2010. Rita Cachão
- December 15, 2010. Edith Doove
- January 19, 2011. Claudy Op den Kamp
- February 23, 2011. Joanna Griffin and David McConville
- March 23, 2011. Hannah Drayson
- April 20, 2011. Martyn Woodward

- May 11, 2011. Amanda Egbe
- June 15, 2011. Business Meeting

Transtechnology Seminar series 2011/12

Transdisciplinarity and Creativity: Translation, Precognition and Intuition
(http://trans-techresearch.net/research/seminars/researchseminars1112-seminar-series)

- September 19, 2011. Michael Punt, Martha Blassnigg and Hannah Drayson
  Introduction to Seminar Series
- October 26, 2011. Edith Doove
  On Translation
- November 23, 2011. Joanna Griffin
  Translation, Space Technology and Representation
- December 14, 2011. Claudy Op den Kamp
  Translsation
- January 18, 2012. Marcio Rocha
  Metaphor as Translation (or the Cherry on the Cake for Human Cognition)
- February 22, 2012. Rita Cachão
  Space, the Sublime and Precognition
- March 21, 2012. Flavia Amadeu
  Intuition and Creative Practice:from a Material to an Immaterial Approach
- April 25, 2012. Theo Humphries
  Considering Intuition in the Context of Design, and of Psychology
- May 23, 2012. Martyn Woodward
  Being Through Painting and Weaving: A Brief Commentary on Intuition (an Artistic Diversion from Writing)
- June 20, 2012. Rita Cachão and Martyn Woodward
  On Deep History and the Sublime: A Brief Introduction

Transtechnology Seminar series 2012/13

Transdisciplinarity: Deep History, Contingency and the Sublime
(http://trans-techresearch.net/researchseminars/seminarseries-20122013)

- September 26, 2012: Michael Punt and Martha Blassnigg
  Cinema, Film, Experience: Deep History, Contingency and the Sublime
- October 17, 2012. Hannah Drayson

Objects, Subjects and Objectivity: Objectivity, Divination and the Sublime

- November 14, 2012. Amanda Egbe with Claudy Op den Kamp, Jacqui Knight and Martyn Woodward
  Practices of Inscription and Recollection
- December 12, 2012. Marcio Rocha with Robert Jackson
  Hope and Reality in Artificial Intelligence (Marcio Rocha) and This is not a Test: Undecidability In-between Machines (Robert Jackson)
- January 16, 2013. Martyn Woodward
  A Bewildering Confusion of Line: Some Deep-Time Aspects of Modern Visual Style
- February 13, 2013. Rita Cachão with Amanda Egbe
  Mediating the Infinite Object
- March 13, 2013.2013. Jacqui Knight with Paul Green
  The Incomplete and Incoherent Fact
- April 17, 2013. TBC
  This seminar coincides with the HERA TEF/CIM KT event and will take place in Amsterdam
- May 15, 2013. Edith Doove with Martyn Woodward
  Categories of Partial Knowledge
- June 12, 2013. Business Meeting

Transtechnology Seminar series 2013/14

Mediation and Transdisciplinarity: Towards an Archaeology of Affection (http://trans-techresearch.net/seminar-series-20132014).

- September 18 2013. Prof. Michael Punt, Dr. Martha Blassnigg and Dr. Hannah Drayson -
  An Introduction
- October 23 2013. Martyn Woodward, An Archaeology of Darwin's 'Tree of Life': Mark-making, Imagination and Becoming
- November 20 2013. Dr. Madalena Grimaldi, The harmonic perception of the contrasting colours.
- December 11 2013. Claudia Loch. A reflection upon Stephen Pinker's 'How the MInd Works'.
- January 15 2014. Jane Hutchinson. Degrees of Lustre: An Experimental Taxonomy of Manifestations, Marvels and Mischwesen,.
- February 26 2014. Marcio Rocha. Cyber-performatives: The cogni-cyber-performative nature of puppetry and ventriloquism and the human interaction with artefacts.
- March 19 2014. Amanda Egbe. Ontologies of the Moving Image: From Paper Prints to Flipbooks
- April 9 2014. Prof. Michael Punt. The Antinomies of Realism
- May 14 2014. Jacqui Knight. The Impossibility of Saying the Event
- June 25 2014. Rita Cachao. 'Real space' revisited- diagram as space

Seminar presented

Metaphor as Translation *(or the cherry on the cake for human cognition)* –
Transtechnology Research, Plymouth University - UK, Marcio Rocha (18/jan/2012).

Hope and Reality in Artificial Intelligence
(12th, December/2012) – Transtechnology Research Seminar

Cyber-Performative Objects
The cogni-cyber-performative nature of puppetry and ventriloquism and the human interaction with artifacts. (February 26 2014) - Transtechnology Research Seminar

Outputs

Written Papers

Rocha, M., Rocha, C. (2010) Realities, images and virtuality – Terminology Taxonomic based on user experience. 9# International Meeting of Art and Tecnology, Brasília – DF – Brazil, 2010. (PG 106-110). [Online]. - Available in Portuguese http://www.fav.ufg.br/9art/nono_art.pdf

Rocha, M. (2011) 'Cognitive Embodied e Enaction são reais perspectivas para o Design de Interação?' Revista Z Cultural. Revista Virtual do Programa Avançado de Cultura Contemporânea da UFRJ, Vol. 7(2) [Online].
- Available at: http://revistazcultural.pacc.ufrj.br/cognitive-embodied-e-enaction-sao-reais-perspectivas-para-o-design-de-interacao-de-marcio-rocha/

Rocha, M. (2011) *Cognitive, Embodied or Enacted? Contemporary Perspectives for HCI and Interaction.* Transtechnology Reader 2011.

Rocha, M. (2011) *Mnemosyne*, Metaphor and Theory of Mind An Imaginative Visual Essay of Computationalism. Transtechnology Reader 2011.

Papers Presented

Rocha, M. (2011) *Cognitive, Embodied or Enacted? Contemporary Perspectives for HCI and Interaction.* Paper presented on Postgraduate Conference for Computing: Applications and Theory (PCCAT) 2012. Paper presented on 6th June 2012.

Invited participation

International Simposium of Innovation in Interactive Media
Media Lab/ UFG / CIAR-UFG, SECULT, CNPq e National network of interactive Art.
Goiânia, GO, Brazil (May, 9 – 11/2012) - (Participation in round-table conference).

Poster Presentations

Cognition Institute research day. Plymouth University, UK. (April 20th, 2012)
Transtechnology Research group.

Rocha, M. and Woodward, M. (2013) 'Transtechnology Research' [Poster design for collective research presentation]. Lure of the New, Cognition Institute launch and conference, University of

Plymouth, Plymouth, UK. 21st March.

Rocha, M. (2013). ‘Mind, Bodies and Machines - To the early automata to the contemporary intelligent being’ [Poster presentation]. Lure of the New, Cognition Institute Conference. Plymouth University, Plymouth, UK. 21st March.

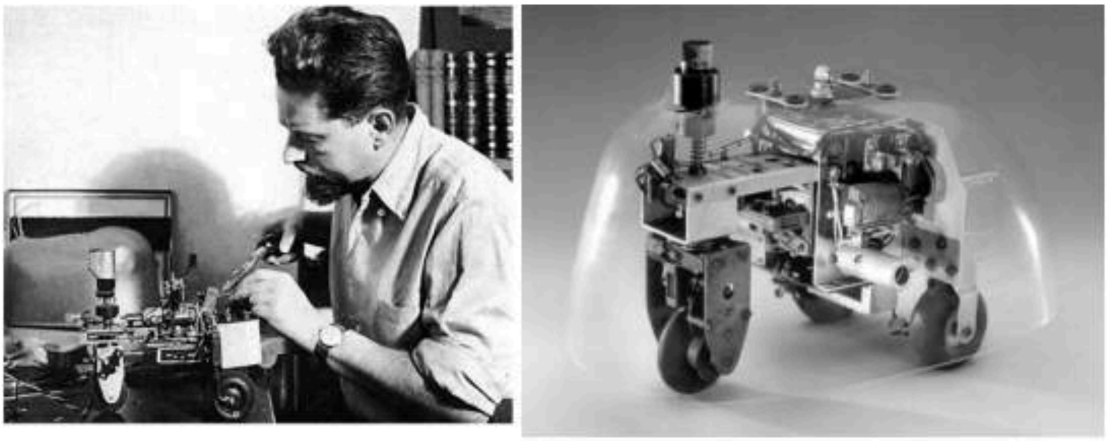
Seminars Presentations

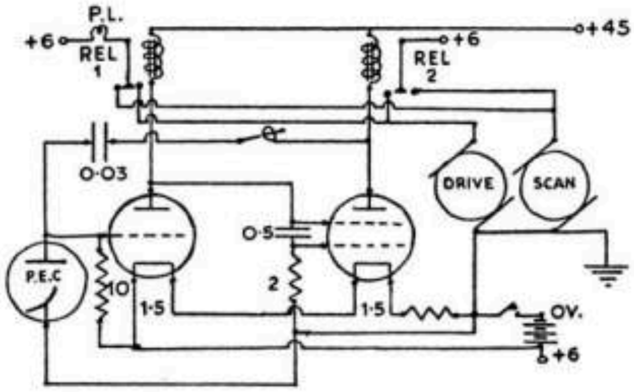
SEMINAR

Cyber-Performative Objects

The cogni-cyber-performative nature of puppetry and ventriloquism and the human interaction with artifacts.

By Marcio Rocha





Abstract

Beginning from the point of view of Cybernetics this seminar will illustrate, through puppetry and ventriloquism, a model to explain the interactive nature of the performative objects in our lives.

Historically, puppetry and ventriloquism as an artistic practice, has being relegated to a niche theatrical practice, ignoring that they function as an art of ‘articulated objects’ that ‘projects, mediates and distribute our cognition and experiences’ and where contemporary theories of interaction can be explored and understood.

Puppetry and ventriloquism relies on a model that can be understood as a ‘system regulated by information and feedback’ which is elucidated to explain the human orchestration with objects from the point of view of our cognitive capacities. This model,

also contrast with the ‘The British Variant of cybernetic’ which, in Pickering’s terms, offers the distinction between the performative and the cognitive aspects, which emphasize machines that ‘act’ rather than machines that ‘think’. The materiality and physicality of these objects and their performative nature, serve as conduits for understanding the world, suggesting a model that exemplifies the performative nature of the human interaction with media-objects that ‘act, express and speaks itself by being act and spoken through’.

This raises the question of how this helps us to amplify our comprehension in terms of the human interaction with computers and digital artifacts?

Through the work of scholars such as Pickering, Minsky, Pangaro, Licklider, Maturana, Clark, Chalmers, Malafouris, Latour among others, the present seminar invites the audience to elucidate and connect subjects and disciplines that at first glance are not clearly connected.

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Malafouris, L. 2008. “At the potter’s wheel: An argument for material agency”. In C. Knappet and L. Malafouris (eds), Material Agency: Towards a Non-anthropocentric Perspective. New York: Springer, 19–36.

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http://www.pangaro.com/definition-cybernetics.html
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http://matt.colorado.edu/teaching/highcog/fall8/c6.pdf
http://web2.ges.gla.ac.uk/~elaurier/texts/Latour.pdf

SEMINAR

Hope and Reality in Artificial Intelligence

12th, December/2012 – Transtechnology Research Seminar

Abstract

Based on an Anthology of HAL-9000, the computer in the science fiction film 2001: A Space Odyssey (1968), Rocha will trace the various phases of AI in order to stimulate some reflections through a critical and philosophical view to inform the design of intelligent machines, addressing some major issues in the field of artificial intelligence.

It will open up a discussion of the interrelationship between developing understandings of HCI and Artificial Intelligence. It will invite basic question about the location and conceptualisation of intelligence and stimulate the consideration of intelligence as an absolute quality that is subject to historical change. The seminar will draw these questions into some basic debates that inform technological approaches to the intimate involvement of humans with machines.

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Pfeifer, R. & Bongard, J. C. (2007), How the body shapes the way we think: a new view of intelligence, MIT Press, Cambridge, MA.
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SEMINAR

Metaphor as translation

(or “the cherry on the cake for human cognition”)

18th, January /2012 - Transtechnology Research Seminar

Abstract

Metaphor, literally know as a figure of speech, uses images, stories or tangible things to represent less tangible things or some intangible quality or idea and can be traced back to the time of Aristotle. Metaphor has been seen within the Western scientific tradition as a purely linguistic construction and more than an ornamental resource of language for film, music and poetry, cognitive linguists, thereby highlighting the centrality of Metaphor to human thought and cognition, have revisited the notion of Metaphor.

Lakoff conceptual metaphor was expressed in his book with Mark Johnson entitled Metaphors We Live By 1980 and suggested that to define our representational system and understand the natural world, “our ordinary conceptual system, in terms of how we both think and act, is fundamentally metaphorical in nature” (p. 3). The essential thrust of Lakoff’s work has been the argument that metaphors are primarily a conceptual construction, and indeed are central to the development of human thought.

Metaphor is frequently used in the design of graphical (user) interfaces as well as in the field of graphic design. The idea that metaphors can ‘translate’ realities goes against some of the more traditional views of Metaphor, and maybe it is reasonable enough to assume that words alone cannot really translate or change reality. However, changes in our conceptual system can operate changes in what is real for an individual and affect how the world is perceived acting upon perceptions.

More than a literal translation, decoding or interpretation of abstract concepts, this seminar will present that this notion suggests that Metaphor is not merely stylistic, but cognitively important as well, structuring our conceptual system and the kinds of everyday activities we perform. This statement suggests somehow that language (and Metaphor) is embodied, embedded and external,

and that the mind is not only contained in the head. The causally active physical vehicles of content and of cognitive processes could be spread across the biological organism and the world.

Other aspects of Metaphor, such as translation, will be used to illustrate and elucidate some aspects of the concept, navigating for other seas, some of which are related to the nature of the ongoing research, such as computational aspects, models, interfaces and visual metaphors.

Is Metaphor the ‘cherry on the cake’ of language and human cognition? We will see…

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Papers and publications

Design de interação e cultura ficcional
Paradigmas, tendências e possibilidades

Interaction design and fiction culture
Paradigms, trends and possibilities

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> **“** I do not fear computers. I fear the lack of them.**”**
> ***ISAAC ASIMOV***

Resumo

O presente artigo expõe um breve panorama sobre alguns dispositivos e artefatos digitais de interação, desenvolvidos e expostos em filmes de conteúdo prioritariamente ficcional (telas, ambientes imersivos, interfaces gráficas, etc) e faz análises e considerações dentro da perspectiva do design de interação, como área do conhecimento.

Estudos culturais e sobretudo amparados na cultura visual, podem se tornar crescentemente importantes e fortes referenciais para o desenvolvimento de dispositivos e artefatos de interação, aliadas as boas práticas metodológicas de design e técnicas de design centrado no usuário. Encontra-se no cerne do design de interação a possibilidade de utilizar-se do caráter interdisciplinar, da observação, da cultura e da etnografia como referencial para a criação de artefatos digitais. Analisar como as pessoas fazem suas tarefas cotidianas, é uma premissa básica para o bom desenvolvimento desses *gadgets* e dispositivos. Todavia é preciso atentar para um fato importante: as narrativas fílmicas apontam tendências e criam direcionamentos importantes para que os designers possam vislumbrar uma perspectiva futura de como poderá vir a ser um mundo povoado de telas e artefatos digitais, entretanto, é importante ressaltar que nem sempre é possível verificar a viabilidade técnica e de interação para esses dispositivos presentes, que invariavelmente, se propõem a construir a narrativa do filme e estão mais voltados para essa condição. Muitas vezes esses produtos, não oferecem condições ideais dentro da perspectiva e dos parâmetros do design para o funcionamento e o uso desses artefatos. Portanto, é parte do objetivo desse artigo, relatar e discutir paradigmas, tendências e possibilidades a respeito desses dispositivos interativos em filmes de ficção.

Palavras-chaves: Design de interação – IXDA – UI – Ficção Científica – Tendências

Abstract

This article presents a brief overview of some devices and digital artifacts of interaction, developed and displayed in movies with fictional content (screen, immersive environments, graphical interfaces, etc.) and makes analysis and considerations from the perspective of interaction design as area of knowledge.

Cultural studies and visual culture, may become reference for the development of devices and artifacts of interaction, coupled with the best practice methodology and design techniques for user-centered design. Interaction design use from the interdisciplinary nature of observation, the culture and ethnography as a reference for the creation of digital artifacts. Analyze how people do their daily tasks is a basic premise for the successful implementation of these gadgets and devices. However we must pay attention to one important fact: the filmic narratives indicate trends and directions for designers envision a future perspective of how you can become a world populated for screens and digital artifacts, however, it is important to note that not always possible check the technical feasibility and interaction for these devices present, invariably, they propose to build the film's narrative and are more focused on this condition. Often these products do not offer ideal conditions within the spirit and design parameters for the operation and use of these devices. Therefore, it is part of the purpose of this article, report and discuss paradigms, trends and possibilities in interactive devices and sci-fi culture.

Keywords: Interaction design – IXDA – UI – Sci-Fi culture – Trends

Introdução

A indústria do cinema é vista como uma fonte permanente de inspiração de como poderá vir a ser o futuro da tecnologia. A cultura presente nos filmes de ficção cientifica apontam para tendências interessantes e ao mesmo tempo contraditórias no que tange sua viabilidade e suas possibilidades. Ainda sobre essa questão, é preciso atentar para o fato de que grande parte dessas tendências constitui um sistema retroalimentado, de tal forma que, não somente o filme de ficção produz elementos inspiradores indicativos que apontam para o futuro da tecnologia e do design de interação, como os designers são constantemente desafiados a contribuir para a criação dessas tendências para a indústria cinematográfica e para o auxilio de suas produções. A viabilidade da implementação dessa tecnologia é discutível. Muitas vezes a tecnologia é utilizada para a construção da narrativa e o bom andamento do enredo cinematográfico sendo uma poderosa influencia cultural para seus entusiastas e sobretudo para o design e para a tecnologia, ao mesmo tempo que trazem contradições importantes sobre tais tendências, possibilidades e sua viabilidade, considerando parâmetros ergonômicos, culturais, entre outros.

Essas preocupações já foram relatadas anteriormente, em setembro de 2009, pelos pesquisadores Nathan Shedroff and Chris Noessel, que apresentaram um *paper* intitulado *"Make It So: What Interaction Designers can Learn from Science Fiction Interfaces", no d´Construct 09´ Conference, em Brighton, UK,* que destaca alguns desses aspectos. Essa apresentação se propunha a relatar alguns aspectos sobre IHC – Interação humano computador nos filmes de ficção, fazendo análises importantes sobre esse aspecto. Esse artigo, pretende contribuir e se somar ao campo teórico da comunidade de pesquisadores que entende os filmes de ficção como parte importante da cultura e conseqüentemente, para o design de interação. Ampliar essa análise, suas possibilidades, assim como também juntar-me como pesquisador que aborda esse tema, para o desenvolvimento do campo de design de interação baseado em estudos culturais esta entre meus objetivos. A idéia de que o designer é um solucionador de problemas, cai por terra na medida em que avaliamos a complexidade de sua atuação nos dias de hoje. Não somente resolver problemas esta no escopo de sua atuação, mas sobretudo, o designer deve ser visto também como um mediador da cultura. A cultura e o projeto voltado para o design de produtos interativos e suas interfaces, exige que o designer atue como um intérprete, e na medida que projeta formas de mediação entre os seres humanos e os objetos que os cercam, há um incremento exponencial nas exigências para a criação de projetos, e sua abordagem se torna também exponencialmente complexa.

Sobre o gênero da Ficção

A ficção científica é uma forma de ficção que compreende o impacto da ciência, verdadeira ou imaginada, sobre a sociedade ou os indivíduos. Geralmente, o termo é utilizado para definir qualquer gênero de fantasia literária que tem a ciência como componente essencial, e num sentido ainda mais geral, para referenciar qualquer tipo de fantasia literária que consista numa cuidadosa e bem informada extrapolação sobre fatos e princípios científicos, ou abranger profundamente áreas complexas, que contrariam definitivamente esses fatos e princípios. Sua construção de forma plausível, baseado na ciência é um requisito indispensável. Há, no entanto, à titulo de informação, muitos casos de obras que se situam na fronteira do gênero de ficção, usando a situação no espaço exterior ou tecnologia de aspecto futurista, apenas como pano de fundo para narrativas, como a série Guerra nas estrelas. Os entusiastas mais tradicionalistas do gênero sci-fi compreendem estes filmes como exemplos de fantasia, enquanto que o público em geral os compreendem no âmbito da ficção científica.

O design de interação e seu campo de estudo

Segundo Preece, Rogers e Sharp (2002), por design de interação entendemos o seguinte: São design de produtos interativos que fornecem suporte às atividades cotidianas das pessoas, seja no lar ou no trabalho.

Se trata de criar experiências que melhorem e estendam a maneira como as pessoas trabalham, se comunicam e enfim, interagem. Winograd (1997) descreve o design de interação como o projeto de espaços para comunicação e interação humana. Consiste em fornecer suporte às pessoas. O design de interação é compreendido como fundamental para todas as disciplinas, campos ou abordagens que se preocupam em pesquisar e projetar sistemas baseados em computador ou dispositivos para pessoas. O campo interdisciplinar mais conhecido é a interação homem-computador (IHC), que se preocupa com o design, a avaliação e a implementação de sistemas computacionais interativos para uso humano e com o estudo de fenômenos importantes que os rodeiam (ACM SIGCHI,1992). Moran definiu esse termo como "aqueles aspectos de um sistema, com os quais os usuários tem contato" (Moran, 1981), o que por sua vez significa "uma linguagem de entrada para o usuário, uma linguagem de saída para a máquina, e um protocolo para a interação dos dois" (Chi, 1985). Os sistemas de informação constituem uma outra área preocupada com a aplicação de tecnologia e da computação nem domínio dos negócios, saúde e educação. Outros campos relacionados ao design de interação incluem fatores humanos, ergonomia cognitiva e engenharia cognitiva, entre outros. Constituem áreas de estudo dedicadas em projetar sistemas que vão ao encontro dos objetivos dos usuários, ainda que cada um com o seu foco e metodologia.

Um dos maiores desafios do design de interação é desenvolver dispositivos que pudessem ser acessíveis e facilmente utilizados por pessoas, além de engenheiros, para a realização de tarefas que envolvessem a cognição humana. Por conseqüência natural da evolução tecnológica, as diferentes áreas de estudo procuram uma relação capaz de abarcar a complexidade envolvida no desenvolvimento desses produtos de maneira que respondam de maneira mais adequada, otimizada e eficaz.

Dentro do processo de design de interação, temos essencialmente quatro atividades básicas, que englobam processos de grande complexidade (Preece, Rogers,Sharp:2002):

- Identificar necessidades e estabelecer requisitos;
- Desenvolver designs alternativos que preencham esses requisitos;
- Construir versões interativas dos designs, de maneira que possam ser comunicados e analisados;
- Avaliar o que está sendo construído durante o processo;

Avaliar o que está sendo construído, está no centro do design de interação. Existem várias maneiras distintas de se atingir esse objetivo: por exemplo, entrevistando os usuários, observando-os desempenhando as tarefas, conversando com eles, aplicando tarefas de desempenho, modelando sua performance, solicitando preenchimento de questionários e até mesmo, pedindo que se tornem co-designers. Envolver os usuários no processo de design de interação. Compreender como as pessoas realizam tarefas do cotidiano deve ser feito antes da construção de um produto interativo.

Um ponto essencial quando se executa uma análise destes fatores é que os usuários não são homogêneos em suas características pessoais e nem em termos de suas necessidades. Apesar de seres humanos partilharem certas características físicas e psicológicas, eles são heterogêneos em termos de qualidades como tamanho corporal, forma, habilidades cognitivas e motivação. Estas diferenças individuais se traduzem em importantes implicações para o design e para o cumprimento de requisitos. As crianças por exemplo, apresentam expectativas diferentes dos adultos quanto a maneira como querem aprender ou jogar. Desafios interativos e personagens animados podem ser altamente motivadores para as crianças, ao passo que para os adultos, podem se tornar algo aborrecido. Em contrapartida os adultos geralmente apreciam discussões sobre tópicos muitas vezes em forma de fórum ou conteúdo textual, sendo que as crianças podem considerá-los maçantes.

Essa diferenças fizeram com que o design de interação recebesse contribuições de diversas outras disciplinas. Não apenas as ciências da computação e a psicologia está envolvida no processo, e para que os estudos nessa área pudessem avançar foram necessárias contribuições da inteligência artificial, lingüística, filosofia, sociologia, antropologia, engenharia, design, entre outras. Dessa forma, é importante notar que subjetivamente, o que pode ser esteticamente agradável e motivador para um indivíduo, pode parecer frustrante para outro. Portanto, é preciso considerar o que as pessoas gostam ou não, e como compreender essas diferenças.

Um dos métodos atuais para a geração de interface, baseia-se na observação detalhada de situações particulares e do cotidiano, compreendendo como os usuários realizam suas tarefas, documentando suas dificuldades ou porque cometem erros no desempenho de tarefas. Nesse caso, a pesquisa aponta para o desenvolvimento de elementos precisos que modelam a concepção do diálogo e a escolha das funções do aparelho.

Paradigmas do design de interação

Segundo Preece, Rogers, Sharp (2002) vários paradigmas de interação alternativos foram propostos por pesquisadores no intuito de guiar futuros designers de interação e o desenvolvimento de sistemas. Dentre eles podemos citar os seguintes:

- Computação ubíqua (tecnologia inserida no ambiente)
- Computação pervasiva (integração total de tecnologias)
- Computação vestível (ou wearables)
- Bits tangíveis, realidade aumentada e integração física/virtual
- Ambientes imersivos (os computadores atendem as necessidades do usuário)
- O Workday World (aspectos sociais do uso da tecnologia)

A industria do cinema e principalmente do cinema de ficção, contemplou a exposição de vários produtos ou sistemas que dialogam com esse princípios alternativos que foram propostos.

O futuro do design de interação

Figura 1 – Imagens do filme Minority Report –Interface de interação baseada em gestos

Interface baseada em gestos

Em *Minority Report (2002)* adaptado de um conto do americano Philip K. Dick, é possível observar um mundo imaginado que se passa no ano de 2054, onde a tecnologia permeia todos os aspectos da vida humana, de uma forma que tanto celebra os feitos da inovação e ao mesmo tempo incorpora as falhas da imperfeição do mundo real. O resultado apresenta um mundo onde os computadores e os seres humanos interagem de maneira significativa e onde cada indivíduo assume tarefas mais adequadas às suas habilidades. A interação é baseada em gestos através da visualização em uma base transparente, onde são visualizados um conjunto de dados, manipulado não somente pelos movimento gestual das mãos, como da cabeça, em uma técnica chamada de *headtracking* para melhoria da percepção de imersão. Esse cenário ficcional une ambiente imersivo, o design da sua interface gráfica, além do design de interação baseada em gestos e movimentos das mãos, da cabeça e do corpo do usuário.

Sobre sua viabilidade, é possível observar marcadores nas mãos do usuário onde alguns movimentos curiosamente não são captados pelos sistema, ou os movimentos gestuais são simplesmente ignorados, sobretudo quando o usuário no filme interage com outros personagens na frente da tela. Essa é um exemplo de um sistema interativo que para a construção narrativa do filme se comporta mais em decorrência dessa construção. Os designers que se propõem a criar esse tipo de interação, precisam programar o que o sistema irá captar como gesto a ser considerado e a ser ignorado. Parte fundamental do processo de entender as necessidades do usuário, consiste em ser claro quanto ao objetivo principal. Nesse sentido é importante refletir sobre o que é realidade e o que é ficção. O que atende requisitos reais e sobretudo dentro da perspectiva do usuário.

Figura 2 – Imagens do filme Minority Report –Interação baseada em gestos através de marcadores

A Oblong desenvolveu um ambiente operacional imersivo denominado g-speak. Se trata de uma plataforma de desenvolvimento de aplicativos em um ambiente de execução baseada em gestos humanos que desafia a navegação imposta pelas GUIs (graphical interface users) tradicionais. Seu desenvolvimento é baseado na proximidade do homem com amplo sistema espacial imersivo, que produz respostas em tempo real, tendo sua navegação, mapeada e modelada pela expressão humana, na busca de uma linguagem natural e fluida. A semelhança não é coincidência: um dos fundadores da Oblong, baseou-se em seu trabalho acadêmico anterior realizado no MIT, e serviu como consultor para a produção do filme *Minority Report* cujos personagens realizam análises forenses utilizando navegação gestualmente conduzida. Revestida de uma realidade mais concreta, o g-speak caminha para se tornar um produto comercialmente viável. Hoje sua aplicação parece lógica e até mesmo necessária. Para o bom andamento do projeto é preciso que os designers e programadores estejam preocupados com as questões humanistas e não somente na tecnologia utilizada para sua viabilidade. Nesse sentido é fácil notar o distanciamento entre a realidade e a ficção.

Figura 3 – Imagens do g-speak –Interação baseada em gestos através de utilização de luvas e marcadores

Ambientes imersivos

Alex McDowell da equipe *Three Ring*, concebeu um ambiente imersivo e intrusivo no qual a identidade de um indivíduo é digitalizada e os conteúdos em torno respondem de forma personalizada as lojas identificam seus clientes pelo nome e sugerem itens baseado em seu perfil. A natureza intrusiva da tecnologia é amplamente enfatizada a fim de servir a narrativa do filme. Os cidadãos estão sujeitos a identificação de suas retinas a cada passo. Tecnologias imersivas similares estão sendo desenvolvidos não só para identificar o participante, mas para controlar os olhos e a cabeça do usuário, permitindo que eles se sintam como se eles coexistem dentro do conteúdo 3D. A tecnologia imersiva busca extrair informações do mundo físico e utilizar essa informação para apresentar-se de uma forma mais real e intuitiva ao usuário. Utilizando um conceito de projeções animadas em grande escala, quiosques interativos e projeções holográficas, o conceito de mídia inevitável e onipresente é ressaltado para a construção poética e fílmica. Em condições e tamanhos superdimensionados a sensação é igualmente ampliada. A aplicação real destas tecnologias começa a dar seus primeiros passos e a discussão ética dessas interações, muito próximas de acontecer na tentativa de se evitar um mundo intrusivo e distópico.

Figura 4 - Ambiente ´vivo e intrusivo´ de Minority Report

Figura 5 - A natureza intrusiva da tecnologia é amplamente enfatizada

Figura 6 - Projeções em grande escala, constroem o conceito de mídia inevitável e onipresente.

Figura 7 – Star Trek - Ambiente imersivo multiscreen 360º

Para a criação do ambiente do filme Star Trek, o designer Scott Chambliss queria projetar a tecnologia em um ambiente onde todas as superfícies são pontos de interação, criando um ambiente de tecnologia onipresente. Para atingir esse objetivo fora utilizado um grande número de computadores com o processamento de conteúdo dinâmico e transmissão de dados, para criar o que parece ser um mundo contínuo em que todas as telas atuam como janelas. Este tipo tendência reafirmado pelo filme, é necessário para que os designers possam melhorar continuamente a estética das interfaces e que criem projeções de vislumbre do futuro, de forma emocionalmente intrigante. Um estudo mais aprofundado da ergonomia, do design informacional e sobretudo de aspectos relacionados ao conforto, podem revelar dados curiosos a respeito do design de interação e da conformação de um ambiente imersivo dentro de uma perspectiva real. Uma questão importante é considerar o isolamento e a grande quantidade de informações e a conseqüente carga cognitiva e o quanto isso pode ser benéfico ou nocivo do ponto de vista do usuário.

Não é preciso ir muito longe na questão da evolução tecnológica e de como isso tem afetado as pessoas em seu cotidiano. Atualmente já é possível verificar essa preocupação. Segundo Julio Van Der Linden (2007) com a evolução das tecnologias, em particular na área da informação e da comunicação, as condições em que vivemos, trabalhamos, estudamos e nos divertimos, enfim os ambientes em que estamos inseridos, têm mudado rapidamente, trazendo inúmeras novidades, nem sempre com resultados positivos para a saúde e o conforto de todos. Atualmente, vivemos uma renovação do pensamento da Ergonomia. O desenho do mundo contemporâneo envolve, além das questões de natureza organizacional, típicas de ambientes de trabalho, questões cognitivas e afetivas implicadas na interação entre o ser humano e a tecnologia.

Digital paper

Ao combinar o conhecimento tátil da mídia tradicional com o poder do serviço remoto de gerenciamento de conteúdo, Minority Report apresentou em algumas cenas, um jornal que cria uma experiência futura de grande potencial, utilizando um papel interativo onde as imagens e noticias se movimentam e interagem com o leitor. Empresas como a E-Ink e Kindle da Amazon e mais recentemente o iPad da Apple, desenvolveram produtos que se inserem dentro de uma lógica muito parecida, e dentro da visão compartilhada de seus usuários. Compreenderam que a chave para qualquer sucesso na adoção de uma nova tecnologia é a fidelidade ao que é familiar dentro da perspectiva humana. Embora pequeno em tamanho, a tecnologia E-Ink tem um grande potencial na expansão do mercado de exibição de dados, unido portabilidade e comodidade aos seus usuários. Outros materiais de visualização flexíveis também estão começando a aparecer, permitindo a visualização da informação de forma portátil, interativa e inovadora.

Figura 8 – Jornal digital – dados atualizados de forma remota em um papel interativo.

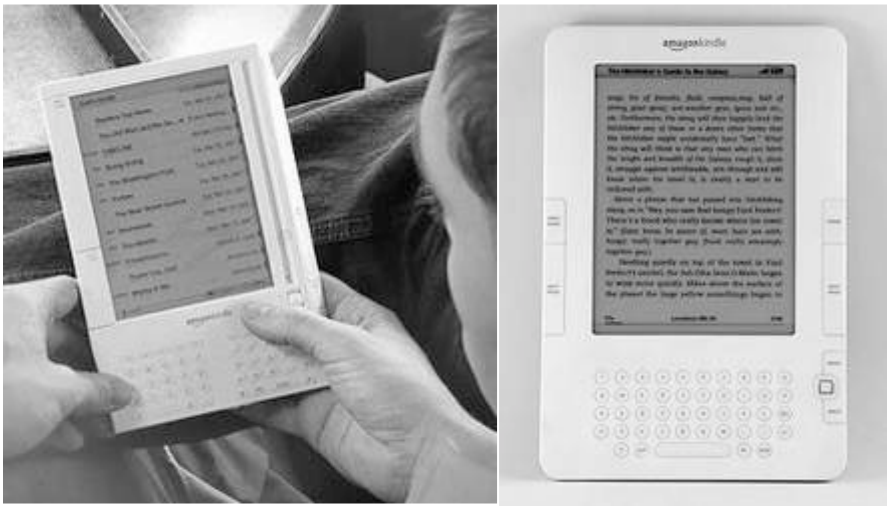

Figura 9 – Respectivamente: Kindle 1 e Kindle 2 da Amazon

Figura 10 – Eletronic paper desenvolvido pela e-ink e IPad da Apple

Head tracking

Introduzido pela primeira vez em capacetes de aviação e cabines de aviões, a navegação baseada no movimentos da cabeça e no movimento dos olhos, o chamado *eye tracking*, permite a apresentação do conteúdo de forma natural e altamente imersiva. Projetando em superfícies translúcidas permite uma experiência de realidade mista, unindo o ambiente natural e conteúdos digitais no mesmo espaço. Esta técnica já esta sendo utilizada em experimentos que se utilizam de uma base um pouco mais ampla, como a utilização de dispositivos móveis e celulares, câmeras e computadores, na utilização de realidade aumentada e realidade virtual.

Figura 11 – Sistema de navegação por head tracking – Minority report (2002) de Steven Spielberg

Figura 12 – Sistema de navegação por head tracking – Iron Man 2 (2010)

Displays e telas translúcidas

A Samsung lançou recentemente seu laptop com tela translúcida com a tecnologia AMOLED - *Active-Matrix Organic Light-Emitting Diode* —, Matriz-Ativa de Emissão de Luz Orgânica por Diodos. É uma tecnologia baseada na OLED, onde os pixels são ligados a um Transistor de Película Fina (TFT, ou *Thin-Film Transistor*).

É possível ver em vários filmes a utilização de telas que oferecem a mesma lógica de visualização de dados. A idéia de dados compartilhados e visíveis mesmo a distancia em qualquer lugar do ambiente se mostra tão interessante quanto ao mesmo tempo contraditória. Questões de privacidade podem interferir na viabilidade de um projeto como esse. É preciso compreender melhor dentro da perspectiva do design de interação, que conseqüências essas telas podem trazer quando da sua utilização no dia-a-dia, como se dará a interação do homem com essas telas e sobretudo, compreender melhor como o homem executa suas atividades dentro dos parâmetros de design de interação.

Por outro lado a aplicação de telas em capacetes e óculos para a utilização de navegação baseada em *headtracking* e *eyetracking*, além da utilização de dados variáveis que transforma a realidade em uma realidade mista e ampliada, com aplicações em pára-brisas de automóveis como exemplo, parece ser uma idéia bem promissora, mas que precede de estudos mais aprofundados.

Figura 14 – Laptop da Samsung com display translúcido AMOLED

Figura 13 – Displays e telas translucidas em Iron Man 2 (2010) e Avatar (2009) de James Cameron

Consideração finais

Os argumentos apresentados neste artigo evidenciam as relações anteriormente supostas entre design de interação e cultura sobre filmes e ficção científica para a criação de produtos de design de interação e artefatos interativos, fazendo avaliações panorâmicas e por vezes empíricas, sobre seus paradigmas, tendências e possibilidades, demonstrando paralelamente produtos ora da ficção, ora do mundo que nos cerca.

A tecnologia caminha a passos largos, de modo que é preciso sempre observar a viabilidade desses projetos, não do ponto de vista econômico ou somente tecnológico que se encontra flutuante, rápido e mutável, mas principalmente da perspectiva do próprio homem e na leitura atenta de seu cotidiano quando da realização de suas tarefas. Observar a praticidade desses projetos dentro da perspectiva do usuário garante que todas as premissas sejam contempladas, de forma a impedir que as decisões não se baseiem somente em atributos estéticos ou em ultima instancia, em produtos somente presentes para caracterizar uma narrativa futurística fílmica, mas distanciada das necessidades cotidianas do próprio homem.

É possível detectar uma dificuldade em se relatar as experiências oriundas da prática da produção voltada para a indústria do cinema que se manifesta de forma antecipatória a novas tendências de mercado sem preocupações técnicas reais, e o seu vínculo com a teoria voltada para o desenvolvimento de projetos de design de interação, que se preocupa com projetos e soluções baseadas em um mundo concreto considerando condições sócio-econômicas, que operam como condicionantes dos projetos de design.

Por outro lado, é possível notar é que a cultura que nos cerca, a análise e a observação desses fenômenos deve ser amplamente considerada para o desenvolvimento de produtos de design de interação, pois apesar de estarem algumas vezes desvinculadas de nossas necessidades reais, sugerem uma quebra de paradigmas e de modelos que representam padrões estabelecidos, que invariavelmente nos impedem de avançar.

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Cognitive Embodied e Enaction são reais perspectivas para o Design de Interação?

Marcio Rocha

Resumo

Alguns movimentos distintos são apresentados nesse artigo. Primeiro, conceitua *Embodiment* e *Enaction 1* dentro do campo teórico das ciências cognitivas. Em seguida, argumenta utilizando esses conceitos, para uma reflexão sobre esse campo teórico e sugere que a partir dessas duas teorias externalistas da filosofia da mente, novos conhecimentos podem emergir de forma a contribuir para o Design de Interação ampliando nosso desenvolvimento teórico sobre o assunto. Teorias externalistas sugerem que a mente e os processos cognitivos que as constituem se ampliam para além da fronteira do corpo do indivíduo. Se nossa compreensão do mundo se dá através da interação de nossos corpos com o ambiente como parte do processo cognitivo, como o campo Design de Interação pode explorar *Embodied* e *Enaction* para tornar nossas interações com a tecnologia mais natural?

Palavras-chave Embodiement – Enaction –Interaction Design.

O campo interdisciplinar das ciências cognitivas têm tradicionalmente se debruçado sobre questões que tentam explicar como nossa cognição é modelada e como nossa compreensão do mundo é construída. Há no entanto, outras noções de computação que figuraram nas histórias tanto das ciências da computação, quanto das ciências cognitivas. A visão externalista explorada atualmente entre os cientistas das ciências cognitivas se refere a teoria do *Embodiement* e *Enaction* trabalhada do ponto de vista fenomenológico de Husserl e Merleau-Ponty, e atualizadas por filósofos e cientistas como Clark (1997) Varela et al. (1991), Thompson (2007), Thompson e Varela (2001), Sheets-Johnstone (1990, 1999), Michael Wheeler (2005), entre outros.

Embodiement fundamentalmente é a premissa de que nossos corpos influenciam a forma como pensamos e que os processos cognitivos estão intrínsicamente conectados aos nossos corpos.

According to the embodied perspective, cognition is situated in the interaction of body and world, dynamic bodily process such a motor activity can be part of reasoning process, and offline cognition is body-based too. Finally embodiment assumes that cognition evolved for action, and because of this, perception and action are not separate systems, but are inextricably linked to each other and to cognition. This last idea is a near relative to the core idea of enaction. (Edwin Hutchins, 428, 2010).

Complementarmente, *Enaction* é a idéia de que nossa experiência do mundo é criado no nosso organismo modelado por nossas ações.

Enaction is the idea that organism create their own experience through their actions. Organism are not passive receivers of input from the environment, but are actors in the environment such that what they experience is shaped by how they act.

Embodiment and enaction are names for two approaches that strive for a new understanding of the nature of human cognition by taking seriously the fact that humans are biological creatures. Neither approach is yet well defined, but both provide some useful analytic tools for understanding real-world cognition (Edwin Hutchins, 428, 2010).

Ambas perspectivas são provocativas na mesma medida em que, ainda que promissoras, não estão totalmente elucidadas. Porém, essas duas premissas indicam que nossos corpos biológicos, não são receptores passivos de entrada do ambiente, mas são atores ativos no ambiente onde suas experiências são moldadas através de seus atos e que o aprender e a nossa compreensão do mundo, ou seja o processo de cognição está não somente conectado com o fazer, como conectado com o mundo real experienciado.

De fato é curioso notar, evidenciada através das observações do nosso quotidiano, o quanto estamos facilmente inclinados a concordar com essas duas premissas. Há uma velha história conhecida no Brasil, que quando você mostra um novo objeto a alguém, seu interlocutor logo deseja tocar e sentir o objeto. Quase que instantaneamente e as vezes preventivamente, o proprietário do novo objeto diz de forma bem humorada e protetora ao seu interlocutor: – Veja com os olhos, não com as mãos! É que para nós, não basta somente olhar, é preciso pegar e sentir o objeto. Essa história cotidiana, apesar de reducionista, ilustra bem um condição enraizada da natureza humana e sugere o quanto nossas interações com os objetos não somente são mediadas pelo nosso corpo biológico, mas também o quanto nossas interações e a nossa percepção dependem de nossa mente encarnada, que percebe o nosso aparelho sensório-motor, gerando a percepção. De fato, a percepção de incompletude é enfatizada quando não tocamos o objeto e nos limitamos somente a olhar para ele. Isso de certa maneira indica que nossos organismos não são somente receptores passivos. Nossos organismos reagem avidamente pela busca da experiência que inclui nosso aparelho sensório-motor que tem predileção por atuar com o ambiente e talvez essa seja a maneira como o nossos corpos biológicos encontraram para se conectar mais naturalmente ao mundo ao seu redor e adaptar-se a ele, ser transformado e moldado por ele e essa perspectiva cognitiva incorporada parece compactuar em grande parte para o nosso processo de raciocínio e aprendizado.

Um outro exemplo que ilustra bem isso é quando estamos interagindo com um aplicativo no computador. Em um certo ponto da interação, (assumindo que se esta navegando em um aplicativo que permita essa relativa imersão) é possível até mesmo esquecer-se que se está manipulando um mouse ou teclado, já que absorvidos pelo conteúdo ou pela tarefa que realizamos, nem sequer notamos a presença do mouse ou teclado, assumindo como extensão do nosso corpo e da nossa mente a pequena seta do mouse que se move diligentemente no monitor. De fato quando nos sentamos em nossos computadores, toda ou grande parte da nossa atenção é captada, incluindo a completude do nossos corpos, mentes e ambientes, já que são inseparáveis e indivisíveis e de alguma forma complementares, sendo difícil precisar ao certo, onde termina um e onde começa o outro. Também em harmonia com nossa condição cognitiva incorporada, Andy Clark (2003), argumenta sobre a facilidade que os humanos possuem em se integrar (seus corpos e mentes) com o mundo artificial e o sistema de objetos que o homem construiu para si próprio:

The accomplished writer, armed with pen and paper, usually pays no heed to the pen and paper tools while attempting to create an essay or a poem. They have become transparent equipment, tools whose use and functioning have become so deeply dovetailed to the biological system that there is a very real sense in which—while they are up and running—the problem-solving system just is the composite of the biological system and these non-biological tools. The artist's sketch pad and the blind person's cane can come to function as transparent equipment, as may certain well-used and well-integrated items of higher technology, a teenager's cell phone perhaps. Sports equipment and musical instruments often fall into the same broad category (2003, p.38).

O clássico exemplo do homem cego com uma bengala que o auxilia no processo de cognição e o integra ao ambiente, se tornou freqüente na literatura desde que Head (1920) mencionou-o pela primeira vez. Como Merleau-Ponty também descreve:

The blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight' (1962, p. 143).

Clark também destaca o processo pelo qual nos tornamos aptos a nos integrar com essas ferramentas, argumentando que não nascemos com as habilidades necessárias, mas que nossos organismos biológicos são moldados para interagir com essas ferramentas, que apresentam diferentes níveis de dificuldade de apreensão de forma a integrar-se com nossos organismos.

Often, such integration and ease of use require training and practice. We are not born in command of the skills required. Nonetheless, some technologies may demand only skills that already suit our biological profiles, while others may demand skills that require extended training programs designed to bend the biological organism into shape (2003, p. 38).

Isso abre um escopo para a compreensão de que a interação não é somente sobre o que está sendo feito, mas também como esta relação é estabelecida. Mais do que isso, coloca definitivamente juntos corpo, mente e ambiente em uma tentativa harmoniosa de compreendê-los conectados, tornando *Embodiement* e *Enaction* perspectivas extremamente interessantes para pensar como a cognição humana opera com o mundo natural e que tipo de conhecimento pode emergir para a compreensão do homem interagindo com as novas tecnologias digitais. *Embodiment cognition*, ou cognição personificada, indica que a nossa mente não está restrita e enclausurada somente em nossos cerébros, e nosso processo mental está distribuído por todo o nosso organismo e a nossa ampla condição de ser vivo no mundo.

Seres humanos e computadores

As ciências cognitivas como estudo da mente e da inteligência, por sua condição interdisciplinar propiciou subsidiar vários campos de investigação, entre elas a Interação humano computador. Apesar dos esforços, o campo da Interação Humano Computador tem tradicionalmente se encarregado de tornar as nossas interações com tecnologia mais amigáveis e naturais, suavizando a relação com métodos e técnicas de aproximação muitas vezes com grande ênfase na tecnologia e pouco foco humanista até então. Muito do que se sabe sobre Interação humano computador são baseadas na noção arcaica das ciências cognitivas que acreditava que as pessoas se comportavam como processadores de informação e que o processo de pensar era muito semelhante ao processo de computar. Grande parte desse pensamento surgiu com as ideias de Alan Turing e e sua máquina de Turing (e, posteriormente, o teste de Turing2) e também com as idéias de Claude Shannon, em 1937, a partir de seu trabalho de mestrado, *A Symbolic Analysis of Relay and Switching Circuits*, que posteriormente contribuiu para a origem do Teoria da Informação.

Gradativamente, pontuais avanços nos permitiram compreender que pessoas e computadores não eram semelhantes e que o processo de pensar seria bem mais complexo do que somente processar informações. Um argumento conhecido como Chinese Room3 (John Searle, 1980) refutava a ideia de que o processo mental era semelhante a computar. Mesmo se um computador simular um comportamento ou um diálogo inteligente, isso não significa necessariamente “pensar”. O ser humano, por sua vez, mais do que manipular símbolos, pensa sobre os símbolos que estão sendo manipulados, operando-os sintática e semanticamente. Trata-se de um processo dinâmico, mais complexo do que computar. O experimento pressupõe de que a sintaxe não garante a existência da semântica e por consequência a produção de significados/sentidos.

Bem mais tarde, ainda dentro desse mesmo espírito fundamentado nessa época, foram desenvolvidos alguns métodos para equalizar as interações do usuário com o computador, na tentativa de reduzir a fricção entre ambos (CARD, MORAN, and NEWELL, 1983). Essas ações poderiam ser físicas, cognitivas ou perceptivas e a utilização desses três ações elementares serviram para o desenvolvimento de técnicas que forneciam informações valiosas para o estudo das interfaces, mas ainda assim apresentavam alguns inconvenientes pois não consideravam o quão seres humanos podem ser afetados por fatores como fadiga, seu grau individual de deficiência, limitações físicas, seus hábitos, personalidades, grau de experiência como usuários e o ambiente social no qual estão inseridos, entre outros.

Seu foco na usabilidade também desconsiderava a funcionalidade do sistema, baseado em um sistema de regras contraditórias de difícil adaptação. A inclusão do uso de personas e técnicas que consideravam a individualidade dos usuários tornaram o foco mais específico e humanista, mas ainda longe de uma resolução definitiva. O campo então passou a integrar diferentes disciplinas e, apesar de propor métodos cada vez mais inclusivos, a tendência do IHC tem sido essencialmente simplificar. O caminho da simplificação sugere ser um caminho lúcido, com muitas preposições advindas da Teoria da Informação. Não se trata somente de reduzir erros, mas de transmitir informações de forma mais eficaz, mas em contraste, a palavra simplificar sugere que apesar dos avanços na compreensão dos métodos, contraditoriamente, o homem ainda continua sendo visto como um processador de informações, que precisa ter suas ações modeladas, os passos ou cliques do mouse calculados, não pode ter sua memória sobrecarregada e precisa ser prevenido constantemente sobre seus próprios ações e erros. Muitas dessas técnicas foram aplicadas com o uso de restrições e da manipulação direta proporcionada pelas Interfaces Gráficas do Usuário (GUI).

O advento das Interfaces gráficas ajudou a popularizar o computador pessoal impulsionando em grande parte a integração entre o homem e o computador, ampliando o acesso antes restrito a cientistas, programadores e técnicos mais especializados, gerando a partir daí, um campo completo de pesquisadores interessados em interfaces computacionais. De fato muito se tem falado sobre interfaces, mas muito pouco ainda se tem feito para penetrar o seu lado humano. A democratização proporcionada pelos computadores pessoais e o advento das interfaces computacionais tornou o computador mais popular, mas nossa interação com a tecnologia não se tornou tão menos complicada e obscura. A mesma interface que supostamente traduziria e tornaria o computador inteligível para a maioria de nós, muitas vezes ao invés de aproximar, divide homem e máquina. Ao separamos superfície de sua estrutura, grande parte do significado se perde entre o mundo físico e o mundo “virtual” e ocasionalmente a interface não reflete as possibilidades do software.

Por que apesar dos avanços sobre o nosso conhecimento sobre nós mesmos são insuficientes para tornar nossa relação com a tecnologia mais natural? As ciências cognitivas têm percorrido esse caminho. Ora demonstrando-se insuficiente para o enfrentamento do problema da interação em amplo aspecto. O ser humano, provido de emoções, consciência, corpo biológico, livre arbítrio e sujeito a condições do ambiente tem se demonstrado muitas vezes incapaz de compreender parte desse novo repertório digital, que tem apresentado um comportamento cada vez mais complexo com o passar dos anos. Supostamente, a forma como refletimos e produzimos o conhecimento sobre nós mesmos, não acompanha a rapidez e a dinâmica envolvida nessa relação. A própria tecnologia se encarrega de nos tornar mais rápidos e de ampliar nossas capacidades, e talvez por consequência torna o processo de reflexão sobre nós mesmos, um tanto quanto mais lento, dada a natureza da própria auto-reflexão e a nova ecologia de produtos em franca expansão tecnológica. Podemos inclusive considerar que nossa capacidade de processar informações com o auxílio das tecnologias progrediu. Na utilização de automação, câmeras de monitoramento, vigilância e controle os computadores demonstram mais eficácia que os seres humanos, assim como em muitas outras tarefas. O jogo de xadrez por exemplo, se tornou um clássico para os cientistas testarem a potencialidade de seus computadores. Para um computador é muito simples “jogar” xadrez e é considerada uma tarefa um tanto quanto difícil jogar em alto nivel para um ser humano. Mas o computador o fará utilizando cálculo bruto e massiva capacidade de processamento operando simulações matemáticas dos prováveis movimentos, mas ainda assim estará distante de “jogar” xadrez em um sentido mais humano do uso do termo. O computador irá prever e calcular os movimentos das peças no tabuleiro, mas ainda está longe de compreender toda a dinâmica que envolve um jogo de xadrez em um sentido ampliado, assim como prever as ações humanas de seu oponente. Um software de computador irá meramente manipular símbolos, operar funções matemáticas, calcular probabilidades, enquanto a mente humana construirá significados a partir do jogo. A competência computacional se encerra na matriz matemática imposta pelo tabuleiro e nas possibilidades das peças do jogo, assim como os limites de movimentação das peças disponíveis. Essa competência está mais relacionada a capacidade de cálculo e processamento do computador, no entanto seres humanos fazem coisas consideradas bem mais complexas, como aprender, compreender poesia, interpretar um texto e apreciar as artes por exemplo.

Isso tudo tem demonstrado que prever as ações humanas muitas vezes tem se revelado uma atividade complexa, e a história recente nos faz crer que há domínios de problemas que os humanos podem pensar e alcançar o conhecimento, mas que não são formalmente computáveis. A conclusão é que conhecer as raízes biológicas por trás das ações humanas parece ser um caminho para compreender a interação das pessoas com as tecnologias digitais e muitos pesquisadores tem trabalhado com temas que consideram essa maior aproximação, como Paul Dourish (2001) e Malcolm McCullough (2004), enfatizando também como os conceitos são socialmente construídos e como a cognição é contextualmente distribuída (HUTCHINS, 1995). Apesar de não constituirem campos essencialmente novos, as pesquisas nessa área indicam uma mudança para o reconhecimento de uma pluralidade de novas perspectivas.

Conectando interação, *embodiment* e *enaction*

Os movimentos acimas descritos procuraram de forma ainda exploratória integrar *Embodiment*, *Enaction* e Design de Interação tendo em vista a compreensão desses fenômenos de forma inter-relacionada com os desafios que o Design de Interação. A mudança dessa visão sugere que o problema está intrinsicamente ligado a mutabilidade das ciências cognitivas e da interação humano computador como campo de conhecimento. De fato o Design de Interação surgiu como uma abordagem alternativa a interação humano computador. O design de interação considera uma aproximação mais plural, não se limitando apenas a nossa relação com os computadores, mas sim a uma gama muito maior de objetos, produtos e artefatos e a complexidade advinda dessa nova ecologia tecnológica, com uma abordagem multidisciplinar e holística. Tendências recentes em design de interação incluem emoção em design, usabilidade e prazer no uso produtos interativos (NORMAN 2004), tecnologia como experiência (McCARTHY e WRIGHT 2004), tecnologias persuasivas (FOGG, 2000), computação afetiva (PICARD, 1997), design afetivo (ABOULAFIA e BANNON 2004), agentes autônomos (TOMLINSON, 2005), design performativo (KUUTTI, IACUCCI e IACUCCI 2002), computação sensível ao contexto (DOURISH 2001b), entre outros.

Já é possível vislumbrar, por exemplo, uma certa aproximação dessa dimensão interativa em alguns produtos. É possivel perceber uma certa movimentação na indústria voltada para o desenvolvimento de produtos que consideram o uso do corpo, utilizando recursos na pesquisa e no desenvolvimento de seu sensores de profundidade, com algoritmos de rastreamento-esquelético, que funciona através da atribuição de cada pixel em uma imagem para uma parte particular do corpo, criando uma imagem difusa do corpo humano onde a profundidade de cada ponto é reconhecido, graças a um sensor infravermelho. O sistema basicamente é alimentado com uma vasta catalogação de dados de captação de movimento que incluem dançar, chutar e correr, além de outros movimentos. Através desses frames captados, partes do corpo são identificadas e o sistema calcula a localização provável das articulações para construir e mapear um esqueleto humano. O algoritmo é executado para o reconhecer o corpo humano, e rastrear os movimentos com a rapidez suficiente para que sejam incorporados ao sistema. Trata-se de uma combinação altamente inovadora de câmeras, microfones e um software que transforma o seu corpo no controle do sistema, ativado por voz, captação de vídeo e reconhecimento facial, com grande potencialidade de aplicação. Longe de ser uma solução definitiva, a qualidade desse produto em específico leva em conta que a mente e o corpo parecem ser equipados com diferentes caminhos pelos quais nós conceituamos a realidade, valorizando a experiência para o aprendizado, a cognição e a descoberta intuitiva, considerando nossa complexa conformação biológica. O que está por trás desse tipo de produto é que a interação considera de forma contundente o corpo do indivíduo como parte do processo de interação e cognição, estimula a autonomia do usuário e cria a experiência sem ignorar o contexto do qual o indivíduo está inserido.

Maturana e Varela fundamentalmente descrevem que o termo enactivismo sugere que a cognição depende de um conjunto dinâmico de relações e associações dependentes do contexto.

Thus we confront the problem of understanding how our experience – the praxis of our living – is coupled to a surrounding world which appears filled with regularities that are at every instant the result of our biological and social histories.

Indeed, the whole mechanism of generating ourselves as describers and observers tells us that our world, as the world which we bring forth in our coexistence with others, will always have precisely that mixture of regularity and mutability, that combination of solidity and shifting sand, so typical of human experience when we look at it up close. (Varella, 1992, pg. 241)

Embodiment em uma tradução livre, significa que o processo cognitivo está incorporado, embutido em nosso corpos. *Enaction* sugere uma espécie de ação futura. Uma espécie de potencialidade de ação e ambos os conceitos estão relacionados. Ainda segundo vários pesquisadores (VARELA, THOMPSON, and ROSCH 1991; THOMPSON, 2005) nós podemos identificar cinco ideias conectadas que constituem a noção de *Enaction.* São elas: autonomia, produção dos sentidos, emergência, incorporamento ou encarnado e experiência *(autonomy, sense-making, emergence, embodiment and experience),* mas que por hora não cabem tanto aqui. O que se mostra interessante nessa perspectiva é considerar o que pode emergir dessa concepção na construção do diálogo com as novas tecnologias. Antes de tudo é preciso primeiro reconhecer o computador dentro de uma perspectiva mais ampliada. O computador não é mais um aparelho limitado somente às nossas mesas de trabalho. Com o avanço da tecnologia, da engenharia da computação e do crescimento do poder de processamento desses aparelhos, aliado a miniaturização, o avanço dos semicondutores e processadores, qualquer objeto pode ser um computador em potencial, desde que carregue consigo potencial para manipular e executar instruções. Muito da ecologia de novos artefatos digitais sofreu radicais mudanças nos últimos anos. Com o advento das redes sem fios e a implementação de tecnologias móveis e telas sensíveis ao toque, uma nova gama de produtos foram criados, desde *laptops, netbooks, notebooks, tablets,* celulares, etc. A diversidade, a onipresença e o tamanho das telas variam desde pequenas dimensões, para telas com a extensão de uma parede ou várias telas de alta definição, redefinindo profundamente a forma de exergarmos a computação e o design desse produtos. Além dessas mudanças, um novo cenário ubíquo e pervasivo promete ser potencializar ainda mais, incluindo gestos, toques, movimentos, vozes, sons podem se tornar formas mais naturais de interação. Mas para isso é preciso construir toda uma nova base crítica para reformular as ciências cognitivas dentro dessa nova perspectiva, baseada no *Embodiement* e no *Enaction*. Esse movimentos já estão ocorrendo gradativamente com pesquisadores interessados em avançar, mas que precisa se solidificar para que os designers possam projetar à luz desses novos conhecimentos.

Conclusão

Diariamente novos produtos são lançados contendo novos códigos, tornando senão todos, parte de nós pouco competentes para lidar com a tecnologia digital e suas diversas formas de interagir. Esses novos produtos, fruto do avanço da tecnologia, tem apresentado um comportamento cada dia mais complexo. O tradicional funcionalismo que dominou o início das teorias que buscavam compreender a relação entre o homem e o computador ainda não se dissipou por completo. Parte do esforço aqui concentrado procura contrapor essa posição prospectando novas possibilidades a partir de uma visão mais contemporânea da compreensão da cognição humana e como isso pode reduzir substancialmente a fricção entre homem e tecnologia. A intenção aqui não é propor o abandono das técnicas e métodos que tem sido úteis aos designers para a criação do diálogo entre homem e a tecnologia digital, nem sugerir que seres humanos compartilham semelhanças biológicas e portanto o design de interação deve considerar uma suposta pasteurização de soluções, mas sim tentar estender a consciência do nível de orquestração e do esforço que é necessário fazer para o design de interação avançar, compreendendo melhor a natureza humana. Até certo ponto, é contraditório que tenhamos dificuldade em nos relacionar com a tecnologia que de alguma forma foi criada pelos homens, para os homens. O que nós ainda não entendemos de fato, a tecnologia ou a nós mesmos?

Infelizmente, estas questões ainda não podem ser respondidas satisfatoriamente. De fato, não há resposta simples para um problema tão complexo. O movimento aqui descrito, ainda que exploratório, procura, de certa maneira, despertar o interesse de pesquisadores em design de interação em atualizar-se sobre os novos movimentos operados pelas ciências cognitivas. A tendência “enativa” vigorosamente defendido por Varela ainda está longe de ter se tornado um paradigma de pleno consenso teórico. No entanto, ele tem o mérito de salientar alguns pontos fracos das ciências cognitivas, em particular a sua tendência a negligenciar fenômenos dinâmicos, autonomia, ação e contexto. As pesquisas e a investigação futura irão mostrar se é possível acomodar alguns desses aspectos da cognição em uma teoria mais abrangente das quais os designers e interessados possam se beneficiar de alguma forma. Sobretudo, essa teoria sugere que nossa interação não é isoladamente representacional, mas encontra-se em movimento para um novo conjunto de relações dinâmicas que devem ser consideradas e isso por sí só representa uma completa mudança paradigmática da compreensão sobre como nós interagimos com o mundo natural, artificial e tecnológico que nos cercam.

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Notes

1 – Embodiment e Enaction são apresentados aqui originamente em ingles, conforme literatura consultada e encontram-se traduzidas, interpretativamente dentro do conteúdo do proprio texto.

2 – O teste consistia em submeter um operador, fechado em uma sala, a descobrir se quem respondia suas perguntas, introduzidas através do teclado era um outro homem ou uma máquina. A intenção era de descobrir se podiamos atribuir à máquina a noção de inteligência.

3 – Chinese Room – ou experimento do Quarto Chines, é considerada uma resposta a teoria proposta por Alan Turing, que basicamente desmistificava a noção de inteligencia por sugerir que manipular simbolos não implica necessariamente em compreende-los.

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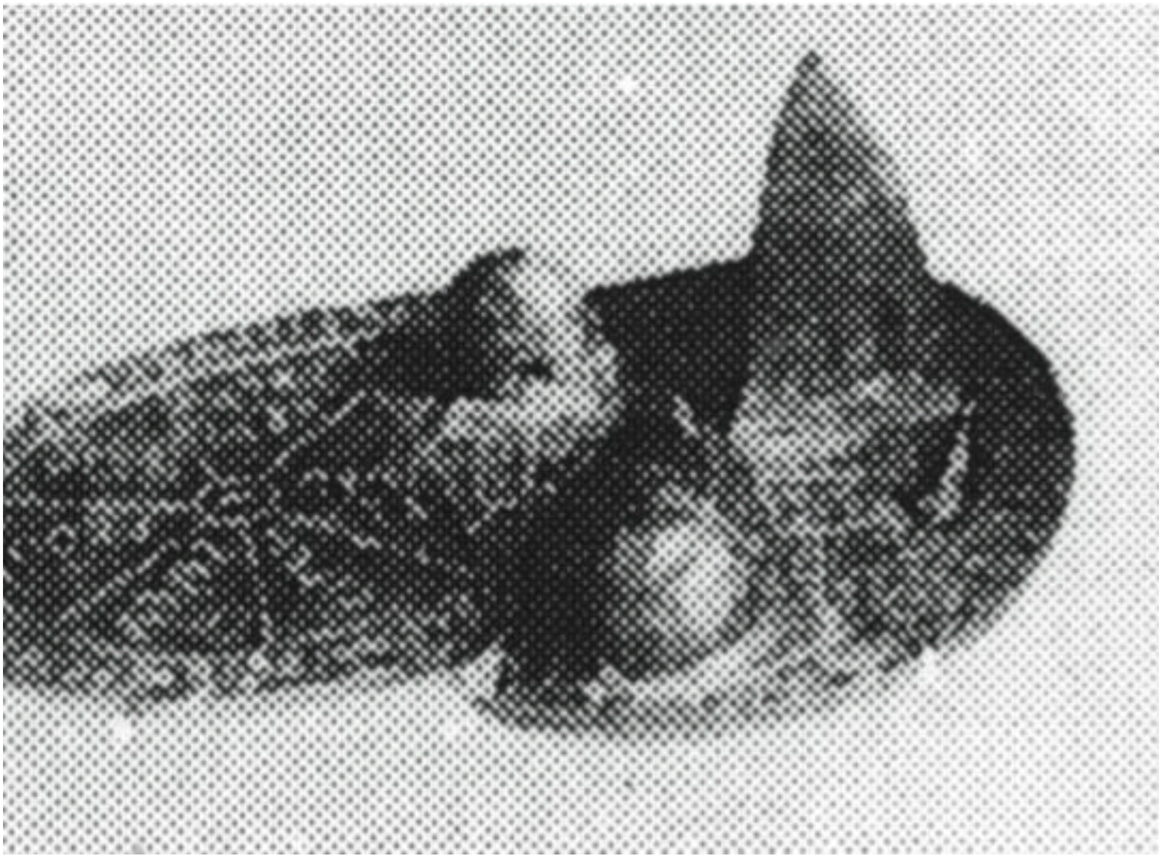
Mnemosyne, Metaphor and Theory of Mind

An Imaginative Visual Essay of Computionalism

Marcio Rocha



Mnemosyne, Metaphor and Theory of Mind
An Imaginative Visual Essay of Computionalism

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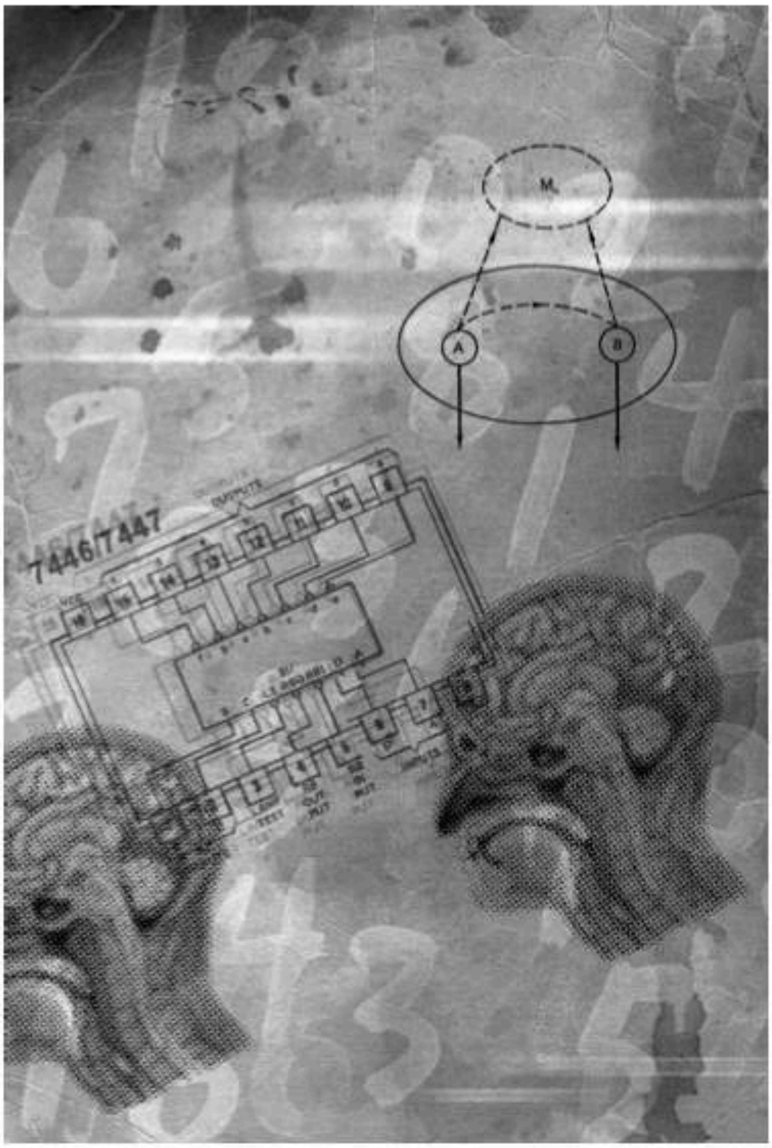
This essay will explore historic principles of a Computational Theory of Mind and metaphor as a cognitive process. The conceptual metaphor developed by Lakoff and Johnson states that "our ordinary conceptual system, in terms of how we both think and act, is fundamentally metaphorical in nature" (1980, p. 3) to define our representational system and understand the natural world. Computational Theory of Mind is a historical view in philosophy in which the human mind ought to be conceived as an information processing system, considering that thought is a form of computation. Externalist theory versions are explored in this essay also, highlighting the tension between central dilemmas and different notions on the subject. Informed by the way that Warburg proposed to represent part of the history of art through juxtaposed images, this essay seeks to open up the possibility to reflect on the history of Computational Theory of Mind, using metaphors and juxtaposed images and will result in visual insights in to the detriment of exclusively textual as evidenced by Warburg in his *Mnemosyne Atlas*.

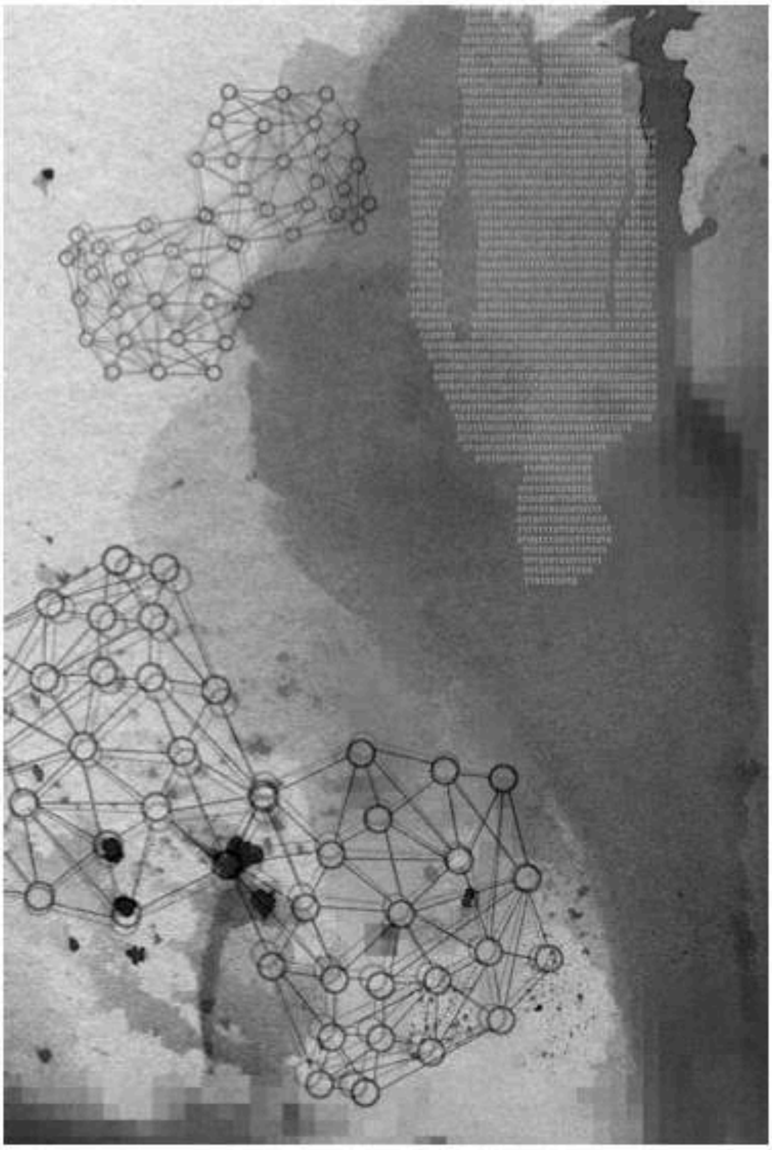
One of Warburg's contributions to the history of art through the *Mnemosyne Atlas*, a contribution which later became more explicit in a science of images, was based on diametrically opposed criteria rather than a pure formalism, and broke with the continuum of art history's traditionally established chronological and hermetic hierarchy. Warburg positioned images to uncover the polarity of the form within incidental ephemera, such as postage stamps and printed materials, constructing imaginative metaphors and uncovering the interpretative energy within them, making metaphor underlying for the work that he proposed. Through his unfinished *Mnemosyne Atlas*, Warburg practised a polarised iconography through images meticulously juxtaposed, reconfiguring the production of human knowledge and understanding, and questioning the meaning of images, as evidenced by the emotive potential each project gathered in his unfinished Atlas (Grau, 2004).

This essay will deal with the following key topics: *Computationalism*, *Functionalism*, *Behaviourism*, *Connectionism*, *Embodiment* and *Enactivism*.

Although the function of the essay is to explore aspects of Computational Theory of Mind it will not be completely detached from the personal/authorial view of the author.

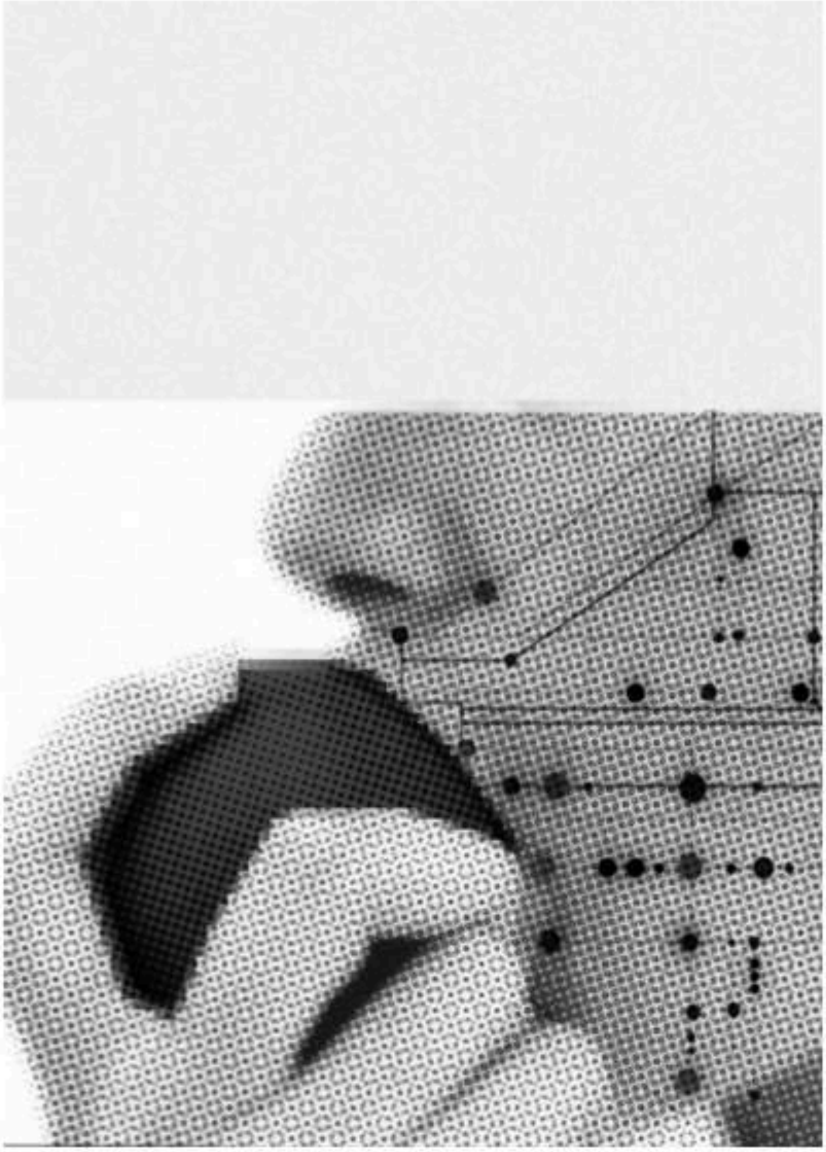


Computationalism is a specific form of cognitivism which argues that mental activity is computational, that is, that the mind operates by performing purely formal operations on symbols, like a Turing machine. **Functionalism/Behaviorism** - Functionalism says mental states are constituted by their causal relations to one another and to sensory inputs and behavioral outputs. While computers are physical devices with electronic substrate that perform computations on inputs to give outputs, so brains are physical devices with neural substrate that perform computations on inputs which produce behaviors. // *This image essentially represents a visual metaphor of computationalism, functionalism and behaviorism emphasising through visual representations, an old notion of the cognitive sciences, it draws a parallel between the way the brain supposedly works and how machines process information.*



Connectionism is the view that mental models or behavioural phenomena act as the emergent processes of interconnected networks of simple units. The most common forms use neural network models. The central connectionist principle is that mental phenomena can be described by interconnected networks of simple, and often uniform, units. Units in the network could represent neurons and the connections could represent synapses. // *This image essentially represents connections through graphical representation and artistic images flowing through the use of watercolours. The idea was to counteract fluid and organic images with the rigidity of the graphical representation of neural networks. This representation is emphasised with the use of the human body, formed essentially by binary codes.*

Embodiment - The idea of Embodiment is based on the concept that the body is linked directly to thought and subsequently to understanding, and that cognitive processes are intrinsically connected to the body. // *In this image there was an attempt to build aspects of the human body, represented by elements like bones, flesh and blood using imagery to draw a parallel with computer codes (HTML). The code is a metaphor for real world experience for the body, which put together body, mind and environment to build a imagery relationship where these elements are indivisibly connected, representing the embodied experience.*



Enaction - Enaction is the idea that organisms create their own experience through their actions. The core idea is that organisms are not passive receivers of input from the environment, but are actors in the environment in such a way that what they experience is shaped by how they act. // *The picture was constructed metaphorically, trying to show the connection between humans, their bodies and the action of eating an apple, which in this case represents the technology and how the human adapts and incorporates it. They are represented together, through the action of human biology and its connection with the artificial world built for ourselves.*

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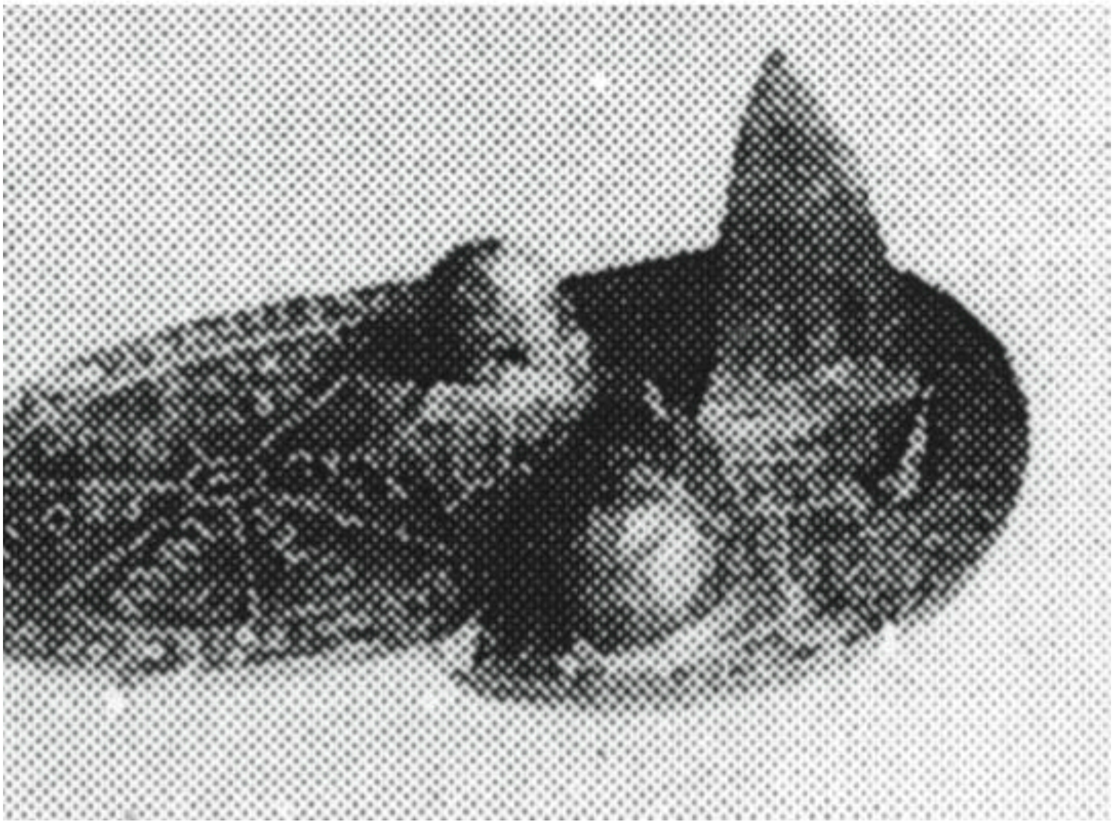
Cognitive, Embodied or Enacted? Contemporary Perspectives for HCI and Interaction

Marcio Rocha



Cognitive, Embodied or Enacted? Contemporary Perspectives for HCI and Interaction

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Abstract

The argument discussed in this paper presents the following movements: first, it presents a brief history of cognitive science and human-computer interaction, raising some considerations arising from the interaction between these two disciplines. Basically the argument here suggests that HCI is still based on the vision known as first-generation cognitive science, where it is still possible to observe how human beings are seen as information processing, treating the act of thinking as an act which is purely computational, neglecting the complexity involved as well as the complexity of human experience. Then it will present the concepts of ***embodiment*** and ***enaction*** as a more externalist vision of cognitive science and philosophy of mind, introducing concepts such as new prospects for the paradigm of interaction. The effort of this paper will be to look for ways to understand how we can translate and apply Embodiment and Enaction in order to improve human-computer-interaction and consequently the interaction design practices.

Historical Paradigms of Cognitive Sciences and HCI

The cognitive sciences, as the study of mind and intelligence, provided by its interdisciplinary condition subsidise various fields of research, understanding how the mind works is important for several human activities, including Human-Computer Interaction (HCI) which traditionally is concerned with the design, evaluation and implementation of interactive computing systems for human use, and with the study of the major phenomena surrounding them [redacted]

The field of Human-Computer Interaction has traditionally been responsible for making our interactions with technology more friendly and natural, smoothing this relationship using methods and approximation techniques, however with frequently emphasis on technology and in consequence, a timid humanistic focus [redacted]. Much of what is known about Human-Computer-Interaction is based on the archaic notion of computation within cognitive science, which maintained that people behave as information processors and that the process of thinking is very similar to the process of computing, know as the first-generation of cognitive sciences. Much of this thinking was based upon the ideas of Alan Turing, his Turing machine and later, the Turing test [1] and Claude Shannon in 1937 from his master's thesis *A Symbolic Analysis of Relay and Switching Circuits*, which later contributed to the origin of information theory.

Gradually, however, there have been some advances in the thinking that people and computers are not similar and that the thought process would be much more complex than just processing of raw data. An example of this argument known as John Searle's Chinese Room [2] (John Searle, 1980) refuted the idea that the mental process was similar to computing. Even if a computer simulated behaviour or an intelligent dialogue, which did not necessarily mean it is able to 'think'. As such, Searle maintained that Humans, in turn, more than manipulating symbols, think about the symbols that are being manipulated, operating them syntaxically and semantically a much more dynamic and complex process than the computional models can sustain.

Much later, still in the same spirit that boosted this time, some methods were developed to equalise the user interactions with the computer in an attempt to reduce the perceived friction between them (Card, Moran and Newell, 1983). These actions, classified as physical, cognitive or perceptual actions, served to develop techniques that provide valuable information for the study of interfaces. However these still had some drawbacks for they did not consider how human beings can be affected by different factors such as fatigue, their individual degree of disability, physical limitations, habits, personalities, or the level of experience of users and the social environment in which they belong.

This focus on usability, inherent within these approaches, also downplayed the functionality of the system, based on a system of rules, which are invariably, complex and difficult to adapt. The inclusion of the use of *personas* and different techniques that consider the individuality of the users became more specifically focused on humans and their human conditions, but were still far from a definitive resolution. The field then began to integrate different disciplines and while proposing more inclusive methods, the central tendency of HCI has been essentially simplified. The way of simplification suggests a lucid way, with many prepositions that come from Information Theory. It is not only to reduce errors, but also to convey information more effectively. In contrast, the word 'simplify' suggests that despite advances in understanding the methods, paradoxically, a human is still being seen as an information processor, who needs to have their actions shaped; steps and mouse clicks calculated, in order to avoid human memory to be overloaded with dates to remember and which needs to be constantly warned about its own actions and errors. Many of these techniques were applied with the use of constraints and direct manipulation provided by the Graphical User Interfaces (GUI).

The advent of graphical interfaces has helped popularise the personal computer driving the integration between man and computer, expanding the access previously restricted to scientists, programmers and technical expertise, generating a field full of researchers interested in computer interfaces (reference). In fact much has been said about interfaces, but little has been done to penetrate the human side of interface. The democratisation afforded by the advent of personal computers and computer interfaces transformed the computer into something more popular, but our interaction with technology has not become less complicated and less obscure. The same interface that supposedly translates the computer and makes it intelligible to most of us, often divides man and machine instead of bringing them together. By separating the surface structure, much of the meaning between the physical and the 'virtual' world is lost and sometimes the interface does not reflect all real potential and possibilities of the software.

The cognitive sciences have travelled this path to make our relationship with technology more natural, but still seems to be insufficient to deal with the problem of interaction in a broader aspect. The human being endowed with biological bodies, emotions, consciousness, free will and subject to all complexity of environmental conditions has many times been demonstrated unable to understand this new digital repertoire that has become increasingly complex over the years. Supposedly, the way we reflect on and produce knowledge about ourselves, is not to follow the speed and dynamics involved in this relationship. Technology itself is responsible for making some aspects more faster and for extending some human capabilities as well. Therefore, this process of reflection about ourselves, determined by the dissonance between the nature of our self-reflection and by the ecology of new products in a faster technological expansion seems to be slower in some way.

Some evidence indicates that the human ability to deal with information supported with technology has progressed. When using automation, video surveillance and control, computers demonstrate to be more effective in many tasks than humans. A game of chess for example, became a classic for some scientists to test the capability of their computers, in order to compare with human capabilities or just to understand the dynamics envolved and can be traced in some research with (Shannon, 1950), (Levy and Newborn, 1991), (Hsu, 2002) and (Lasar, 2011) among others. For a computer it is very simple to "play" chess, even though for a human being it is considered to be a somewhat difficult task to play at a high level. Using the computer will calculate the gross and massive processing power operating mathematical simulations of likely movements, but it still is far from 'playing' chess in a more human use of the term. The computer will calculate and predict the movements of the pieces on the board, but it is still far from understanding all the dynamics that are involved in a game of chess in an amplified sense, as well as from predicting the actions of its human opponent. Computer software will merely manipulate symbols, operate mathematical functions, calculate probabilities, whereas the human mind constructs meaning from the game. The computer competency in a mathematical matrix ends by the limits imposed by the board, the possibilities of game pieces, as well as the movement of parts available. This expertise seems more related to computing capacity and processing power, but humans have particular competencies to do things considered more complex, such as learning, understanding poetry, interpreting a text and appreciate the arts.

As the literature has shown, to predict human actions has often proved to be a complex activity, and recent history makes us believe that there are areas of problems in which humans can attain knowledge, but are not formally computable. The conclusion is that knowing the biological roots behind human actions seems to be one way to understand people's interactions with digital technologies. Many researchers, such as Paul Dourish (2001) and Malcolm McCullough (2004), have worked on topics they consider this closest approach considering our embodied mind, emphasising how the concepts are socially constructed and how cognition is distributed contextually (Hutchins, 1995). Although not essentially new fields, research in this area indicates a shift towards the recognition of a plurality of new perspectives.

Embodiment and Enaction Perpectives

There are, however, other notions of human cognition, which figure in the histories of both computer science and cognitive science. Contemporary accounts of human cognition within the cognitive sciences depart from the computational views of old to address an 'externalist' view held amongst cognitive scientists and philosophers, primarily concerning the theory of Embodiment and Enaction. Such works depart from the computational models through the phenomenological enquiries of Husserl and Merleau-Ponty, updated by philosophers and scientists such as Clark (1997), Varela *et al.* (1991), Sheets-Johnstone (1990, 1999), Thompson and Varela (2001), Wheeler (2005), and Thompson (2007) amongst others.

The concept of Embodiment is based on the premise that the body is linked directly to thought and subsequently to understanding, and that cognitive processes are intrinsically connected to the body:

> According to the embodied perspective, cognition is situated in the interaction of body and world, dynamic bodily process such a motor activity can be part of reasoning process, and offline cognition is body-based too. Finally embodiment assumes that cognition evolved for action, and because of this, perception and action are not separate systems, but are inextricably linked to each other and to cognition. This last idea is a near relative to the core idea of enaction (Hutchins, 2010, p. 428).

In addition, Enaction is the notion that our worldly experience is created through the body shaped by our actions:

> Embodiment and enaction are names for two approaches that strive for a new understanding of the nature of human cognition by taking seriously the fact that humans are biological creatures. Neither approach is yet well defined, but both provide some useful analytic tools for understanding real-world cognition. [...] Enaction is the idea that organisms create their own experience through their actions. Organisms are not passive receivers of input from the environment, but are actors in the environment such that what they experience is shaped by how they act (Hutchins, 2010, p. 428).

Both concepts remain provocative within the literature of cognitive science to the extent that, although promising, they are not completely elucidated. However, these two assumptions provide a platform in which the body can be understood not as a passive receiver of environmental input but as having an active role in the environment in which experiences are shaped by bodily actions. Such an account implies that human learning process of cognition is not only connected with bodily doing but also especially connected with a real world experienced.

Despite their provocative nature, it is curious to note, as in the following examples, how we are easily inclined to agree with these two assumptions drawn from embodiment. Consider the following thought experiment. When someone is shown a new object, they are often inclined to want to touch and feel the object. Almost instantly and sometimes preemptively, the person showing the object tells the person looking at it, rather humourously: please, look at it with your eyes and not with your hands! Where only looking seems insufficient, it seems necessary to pick up and to feel the object. This everyday story, though simplistic, illustrates a condition rooted within human nature which suggests how interacting with objects is mediated not only by the biological body, but also by interactions themselves rest upon embodied perception. The perception of incompleteness is emphasised when the object is not touched. This seems like an indication of human bodies not only being just passive receiver of information, but avid reactors to their experience, which includes a sensory-motor that has a predilection for acting with the environment. That might be the way in which biological bodies have found to connect more naturally to the world around them, adapt to it, be transformed and shaped by it, supporting a cognitive perspective *embodied* in large part to the human process of thinking and learning resulted by human experience and rejecting the traditional view of computation over representations, emphasizing *embodied action* as a more appropriate term.

> By using the term *embodied* we mean to highlight two points: first that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context. By using the term *action* we mean to emphasize once again that sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition. (Varela *et al.*, 1991, p. 173).

Another example that illustrates the embodied nature of experience is the interaction with an application on a computer. At one point of the interaction (assuming this is an application that allows this relative immersion), the user forget that a mouse or keyboard is present and being manipulated, as they are absorb into the content or task accomplished, as Andy Clark (2003):

> The accomplished writer, armed with pen and paper, usually pays no heed to the pen and paper tools while attempting to create an essay or a poem. They have become transparent equipment, tools whose use and functioning have become so deeply dovetailed to the biological system that there is a very real sense in which—while they are up and running—the problem-solving system just is the composite of the biological system and these non-biological tools. The artist's sketch pad and the blind person's cane can come to function as transparent equipment, as may certain well-used and well-integrated items of higher technology, a teenager's cell phone perhaps. Sports equipment and musical instruments often fall into the same broad category (Clark, 2003, p. 38).

Another often used example is that of a blind man with a walking stick, which assists him in the process of cognition and integrates him in his environment, (as initially described by Head (1920)). As Merleau-Ponty describes:

> The blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight (1962, p. 143).

Clark also emphasises the process by which we become able to integrate these tools in arguing that we are not born with the necessary skills, but biological organisms are shaped to interact with these tools, with different difficulty layers of apprehension in order to integrate with our bodies:

> Often, such integration and ease of use require training and practice. We are not born

> in command of the skills required. Nonetheless, some technologies may demand only skills that already suit our biological profiles, while others may demand skills that require extended training programs designed to bend the biological organism into shape (Clark, 2003, p. 38).

Embodied and enacted models of cognition open a scope for interaction being understood not only in terms of what is being done (as in the computational approaches), but more fundamentally how relationships between people and technologies develop. These approaches recognize that body, mind and environment work in harmony and attempt to understand them as connected and co-dependent. These conditions make embodiment and enaction interesting perspectives for thinking about how human cognition works in relation to the natural world and what kind of knowledge can emerge for understanding how humans can interact with digital technologies. Particularly when applied to the field of Human Computer Interaction (HCI), which has recognised cognition not as linked to bodily action, but passive receivers of information.

Connecting Interactions, Embodiment and Enaction

The movement described above sought to integrate Embodiment, Enaction and Interaction in order to understand these phenomena inter-relatedly, which is a challenge to Human Computer interaction and interaction as a whole. To change this view suggests that the problem is intrinsically connected to the mutability of the cognitive sciences and Human-Computer-Interaction as a field of knowledge. In fact interaction design has emerged as an alternative approach to Human-Computer-Interaction considering a more plural point-of-view, which is not limited only to our relationship with computers, but connects to a much wider range of objects, products, artifacts and complexity, which results from this new technology ecology, with a multidisciplinary and holistic approach. Recent trends in interaction design for instance include, emotion in design; Technology as Experience (McCarthy and Wright, 2004); usability and pleasure in interactive products (Norman, 2004); persuasive technologies (Fogg, 2000); affective computing (Picard, 1997); affective design (Aboulafia and Bannon, 2004); autonomous agents (Tomlinson, 2005); performative design (Kuutti, Iacucci and Iacucci, 2002) and context sensitive computing (Dourish, 2001b), among others.

It is thus possible to discern, for example, a certain approximation of this interactive dimension in some products. You can see some movement in the game-industry focused on developing products that consider the use of the body, using resources in research and development of its deep sensors, and with skeletal tracking algorithms, which work by assigning each pixel in an image to a particular part of the body, creating a fuzzy picture of the human body where the depth of each point is recognised, using infrared sensors. The system is primarily fed a vast catalogue of data of captured movements that include dancing, kicking and running. Through these captured frames, body parts are identified and the system calculates the probable location of the joints and maps this information to build a human skeleton. The algorithm is implemented to recognise the human body and track the movements quickly enough to be incorporated into the system. It is a highly innovative combination of cameras, microphones and software, which turns your body into a control system, with voice-activation, video capture and facial recognition, with great potential for application.

Still far from being a definitive solution, the quality of this specific product takes into account that the mind and body seem to be equipped with different ways in which they conceptualise reality, enhancing the experience for learning, cognition and intuitive discovery, given the complex human biological conformation. The rationale behind this type of product is that it considers the interaction of an individual's compelling body as part of the process of interaction and cognition; encourages autonomy and creates the user experience without ignoring the individual's context.

Maturana and Varela describe the term Enactivism, which suggests that cognition depends on a dynamic set of relationships and context-dependent associations:

> Thus we confront the problem of understanding how our experience – the praxis of our living – is coupled to a surrounding world, which appears filled with regularities that are at every instant the result of our biological and social histories. [...] Indeed, the whole mechanism of generating ourselves as describers and observers tells us that our world, as the world which we bring forth in our coexistence with others, will always have precisely that mixture of regularity and mutability, that combination of solidity and shifting sand, so typical of human experience when we look at it up close. (Maturana and Varela, 1992, p. 241)

Embodiment means that the cognitive process is embedded in our bodies and Enaction suggests a future potential action and both concepts are related. Also according to several researchers (Varela, Thompson and Rosch 1991; Thompson, 2005) we can identify five linked ideas that constitute the notion of Enaction. These are Autonomy, sense-making, emergence, embodiment and experience, but for now does not fit well here. What seems interesting in this perspective is to consider what kind of dialogue can be formalized with the new technologies. First the computer must be recognise within a broader perspective. The computer is no longer a device cloistered only to our desks. With the advancement of technology, computer engineering and the growth of processing power of these devices, coupled with miniaturisation, the advancement of semiconductors and processors, any object can potentially be a computer, since it would carry with it the potential to manipulate and execute instructions. Much of the ecology of new digital artifacts has undergone radical changes in recent years. With the advent of wireless networks, mobile technologies and implementation of touch screens, a new range of products were created, such as laptops, netbooks, notebooks, tablets and phones. In addition to these changes, the pervasive and ubiquitous computing promises to increase the complexity of this new scenario, including new ways to interacting with digital artefacts, including gestures, touches, movements, voices and sounds, becoming new forms of interaction. Within this new perspective - cognitive science based on Embodiment and Enaction - HCI could move beyond the problems inherent within a computational model.

Conclusion

Part of the effort here seeks to counter this position focused on prospecting new possibilities from a more contemporary understanding of human cognition and how it can substantially reduce the friction between man and technology, especially toward for HCI and Interaction design. In the history of cognitive sciences, some kinds of representations and computations were developed to understanding human thought, including computational-representational account now available does justice to the full range of human thinking. As some evidence points, the idea of embodiment and enaction contradicting the idea that the cognitive process occurs only through the representation and more than that, externalist theories suggest that the mind and cognitive processes are extended beyond the border of the individual's body. In addition, Embodied and Enacted cognition opens a scope for understanding that interaction is not only in terms of what is being done, but more fundamentally how this relationship is established. The effort this argument, are presented elements for a theoretical reflection suggesting that from these externalist theories of Philosophy of Mind new knowledge can contribute to HCI and Interaction Design founded upon computational theories of mind, expanding theoretical development on the subject.

Particularly when applied to the field of Human Computer interaction (HCI), which has recognized cognition not as linked to bodily action, but passive receivers of information. The traditional functionalism, which dominated the beginning of the theories that sought to understand the relationship between man and computer, has not completely dissipated.

The embodied and enactive trend proposed by Varela cannot be considered a full consensus in this theoretical paradigm. However, it has the merit to highlight some internal fragilities in the cognitive sciences, in particular its tendency to neglect dynamic phenomena, autonomy, action and context, characteristics that must not be neglected on the autonomy of human beings and should be considered for the HCI to develop more inclusive interactions. Current and future research will show whether it can accommodate some of these aspects of cognition in a more comprehensive theory from which the designers and interested parties can benefit in some way. Above all, this theory suggests that our interaction alone is not reduced to a representational model only, but is moving to a new set of relationships that should be considered and this in itself represents a complete paradigm shift in understanding how we interact with the natural and artificial world and with the technology around us. Thus, this essay is nothing more than part of the effort to questioning, understand and contribute for this phenomenon can be better understood. Embodied cognition and Enactive perspectives can be translated and applied to the development of best practices for HCI and interaction design? The future will tell us.

Notes

[1] Turing Machine/Test - The test consisted of submitting an operator in a closed room, to discover whether those who answered their questions, introduced by the keyboard was another man or a machine. The intention was to find out if we could assign to the notion of machine intelligence.

[2] Chinese Room - or the Chinese Room experiment is considered a response to the theory proposed by Alan Turing, who largely demystified the notion of intelligence to suggest that by manipulating symbols it is not necessarily to understand them. The argument is intended to show that while suitably programmed computers may appear to converse in natural language, they are not capable of understanding language, even in principle. Searle argues that the thought experiment underscores the fact that computers merely use syntactic rules to manipulate symbol strings, but have no understanding of meaning or semantics (Stanford Encyclopedia of Philosophy).

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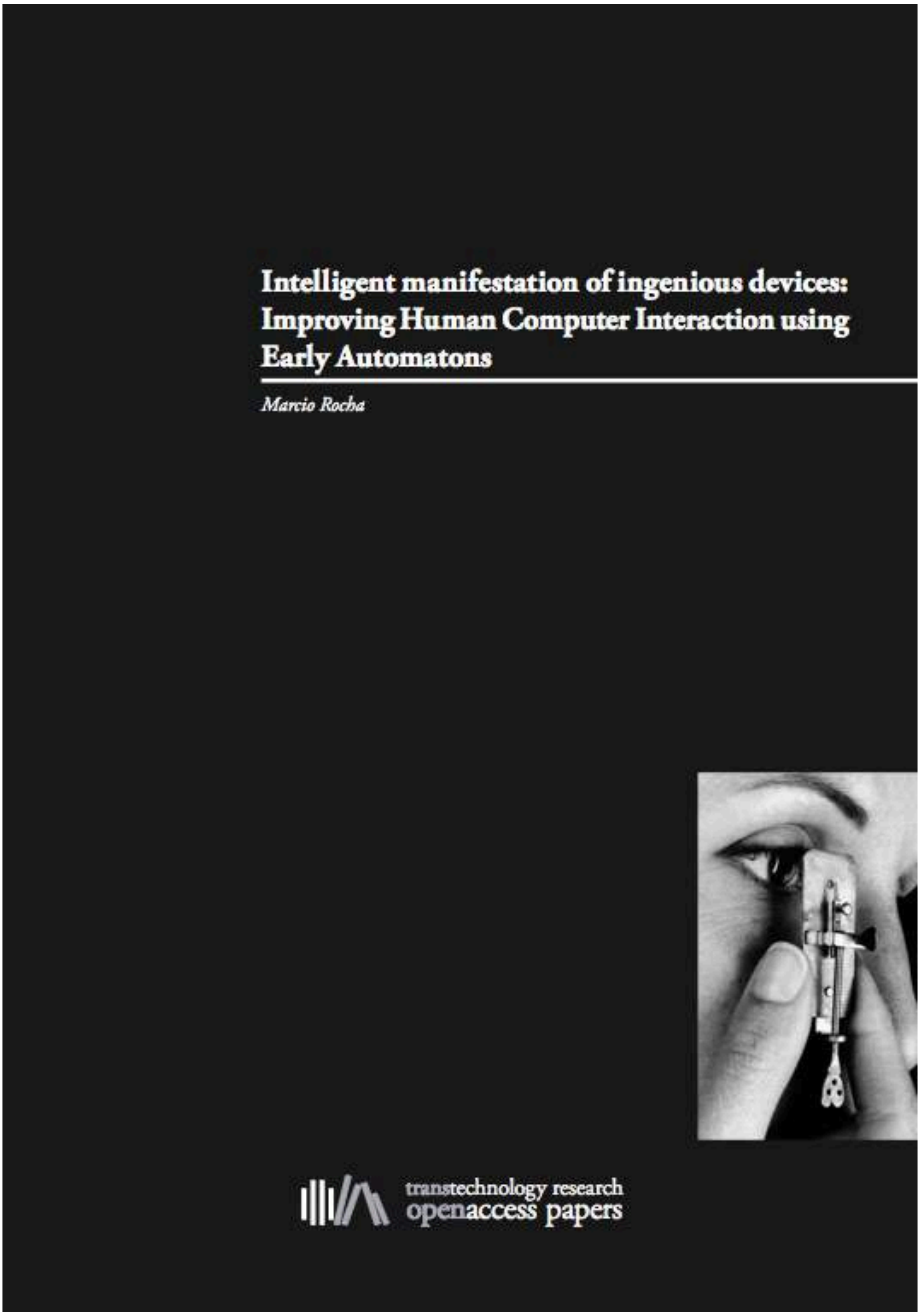

Intelligent manifestation of ingenious devices: Improving Human Computer Interaction using Early Automatons

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Intelligent manifestation of ingenious devices: Improving Human Computer Interaction using Early Automatons

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Abstract

The follow paper present the follow movements. First, using as a main literature the Standage's book 'The Turk: The life and times of the famous eighteenth-century chess- playing machine', the present paper, explain the secrets of this fascinating machine know as 'The Turk', made by Wolfgang von Kempelen in 1770. The Turk Chess-playing machine could simulate during years, a mechanical automata device playing authentic chess without have had its fraud revealed In the second part, this paper aims to make connections between the characteristics of this artefact and how it can be used to develop a analogy about cognition and our interaction with objects and machines. Although The Turk chess player, was just a illusion for their spectators, this machine is used here to explain some ideas and concepts, connecting materiality, physicalism and cognition through objects, connecting mind, body and environment within a model of distributed and embodied mind. That said, the intention of this paper is propose a critical model of thinking about Human Computer Interaction, using early automaton as an elucidative model in which intelligence is manifested by interaction, which is the main subject of this Ph.D research on going.

"Introduction

Partially dedicated to mythologies of artificial, automatons and mechanical machines, the present research in progress, is toward to the Human Computer Interaction development and design, which intend to amplify our comprehension about various aspects of a relationship between humans and machines. For this, one specific early mechanical machine know as 'The Turk', is explored in this essay to explain some concepts that are part of the research.

The Turk is a mechanical machine and a chess-player automata made by Wolfgang von Kempelen in 1770, and although it was designed as an elaborated hoax for a magic trickery, Kempelen's mechanical chess player speaks eloquently of the harmonic cooperation between the elements (human and mechanical) responsible to afford the trick in a way that appeared to the audience as a seamless unity and render the trick invisible, playing chess and intimidating his opponents for more than seven decades. Already in his time, the invisible power of this ingenious and elaborated device suggested a deep discussion of artificial intelligence, questioning whether a machine could be more intelligent than a human and if logical thinking could be mechanical formalized, in addition to stimulating a range of other philosophical issues.

In this research, 'The Turk' has been used to suggest that in HCI practice, rather than just develop interaction based on representations, it is possible to think more about the possibility of users actively thinking distributively, through devices (or objects) in our interaction solutions. Drawing on this model, this paper

Wolfgangs von Kempelen
k. k. wirklichen Hofraths
Mechaniſmus
der
menſchlichen Sprache
nebſt der Beſchreibung
ſeiner ſprechenden
Maſchine.
Mit XXVII Kupfertafeln.

Haſce igitur penitus voces cum corpore noſtro
Exprimimus, rectoque foras emittimus ore,
Mobilis articulat verborum dædala lingua,
Formaturaque labrorum pro parte figurat.
Lucret. lib. IV. v. 553.

Wien,
bey J. V. Degen, 1791.

Fig. 1 - Racknitz wrongs assumptions - Based on his own observations, Joseph Friedrich Freiherr von Racknitz published the book 'Ueber den Schachspieler des Herrn von Kempelen, nebst einer Abbildung und Beschreibung seiner Sprachmachine', with illustrations explaining how he believed The Turk machine operated. Later his assumptions about how the Turk works has proved to be wrong. (Standage, 2002, p. 198-199).

presents images of The Turk machine to illustrate useful concepts for the contemporary development of HCI presenting a different model of mind (embodied mind) and the possibility of interactions consequent upon 'intelligent' s of the 'artificial' world, focusing on the physicality of 'media'.

It is proposed to advocate thinking through devices as contemporary alternatives in Human computer interaction development. Not just a simulation of the world, as for instance, the Graphical User Interface (GUI) dominant paradigm, but using the 'world' itself as its best 'representation' and therefore, central for cognitive processes.

The secrets of the Turk

The Turk or the Mechanical Turk was an automaton constructed by Wolfgang von Kempelen in the late 18th century capable to convince the audience that the automaton was able to play chess, formalizing mechanically logical thought in a restricted domain. In fact its secret consisted in a human chess master player operating the machine inside of the cabinet, to produce a mechanical illusion that persisted for decades. Its secret was never publicly exposed with a reliable full explanation, there remained much conjecture around how it actually worked, until being destroyed in a fire in 1854.

In The Turk: The life and times of the famous eighteenth-century chess- playing machine, Standage (1996, pp. 194-180) dedicate an en-

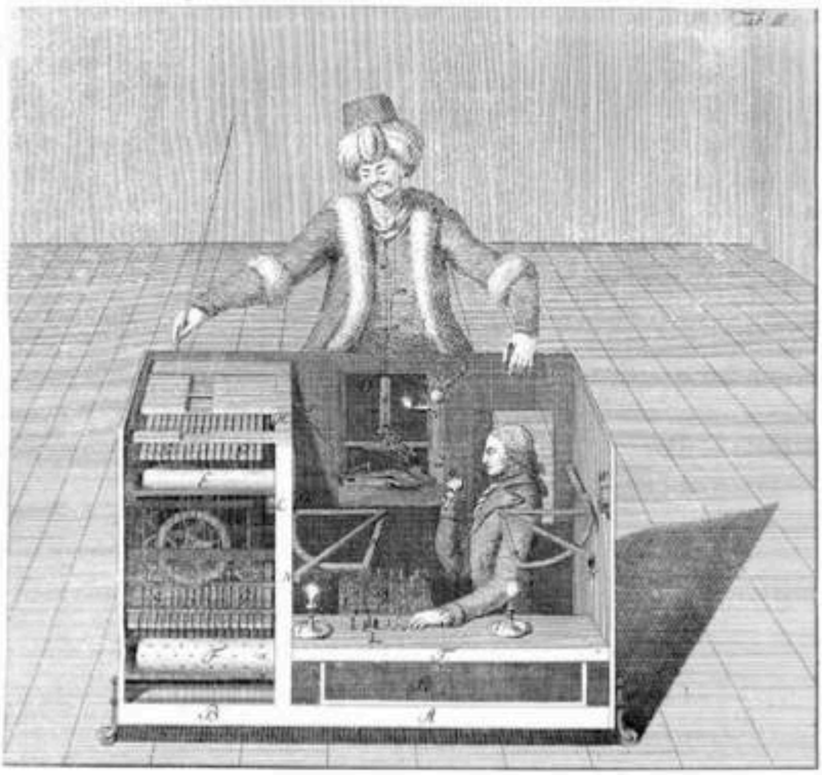

Fig. 2 - "Racknitz wrongly concluded that the operator had to fit solely into the space behind the machinery, there was even enough room for the operator to sit up. So there was no need for the operator to be a child, a dwarf, or an amputee; the cabinet was capable of concealing a full-size adult." As Standage describe, "The Clockwork machinery visible on the Turk's left-hand side (as seen by the audience) did not, extend all the way to the back of the cabinet, behind the drawer was pulled out, it appeared to have the same depth as the cabinet. (Standage, 2002, p. 87)

tire chapter to explain and describe the Turk secret's, after a few decades of speculation. According to Standage, It was only in 1857 that an authoritative account appeared, written by Silas wier Mitchell, whose father had been the Turk's last owner. The Turk's secret took the form of a series of articles titled "Last of the Veterans Chess Player," which were published in Chess Monthly, a New York Magazine.

As Standage suggests, "Mitchell's description of the account was based on Mitchell's own recollections and some notes made by his father. It repeats a number of myths about the Turk (such as its having played agains George III and Louis XV) and contains several errors relating to the manner of the Turk's presentation. But Mitchell's articles, together with other documents dating from the Turk's last days in Philadelphia, make possible a full explanation of the automaton's secret" (ibid).

> "As had been widely suspected, the Turk was indeed controlled by an operator concealed inside the cabinet, who remained there throughout the performance. There was no need for wires or pieces of catgut, nor for trapdoors beneath or behind the automaton. Nor was the automaton's strategy guided in any way

> by the artful use of exterior magnets". (ref)

Concluding that in fact, the exhibitor outside the cabinet had no direct control over the automaton's actions and strategies as part of the trick to make it plausible.

Standage's description of the plates

(Plate 1) - At the start of the performance, the operator moved forward on the sliding seat (which was mounted on greased iron rails running along the back of the cabinet), raised his knees, and leaned forward, assuming a somewhat uncomfortable position. The movement of the seat caused a small amount of dummy machinery visible through the cabinet's leftmost door (as seen by the audience). It was then possible for the exhibitor to open the small door at the back of the cabinet and hold a lighted candle up to it, whose flickering could just be seen through dense machinery that now seemed to extend all the way to back of the cabinet.

(Plate 2) - Once the exhibitor had removed the candle and shut the rear door, the operator straightened his legs and slid backward on the moving seat. This caused the dummy machinery to fold up and also closed a small window behind the front most machinery through which the light of the candle had shone. This ensured that there was no danger that the operator, now sitting up behind the clockwork

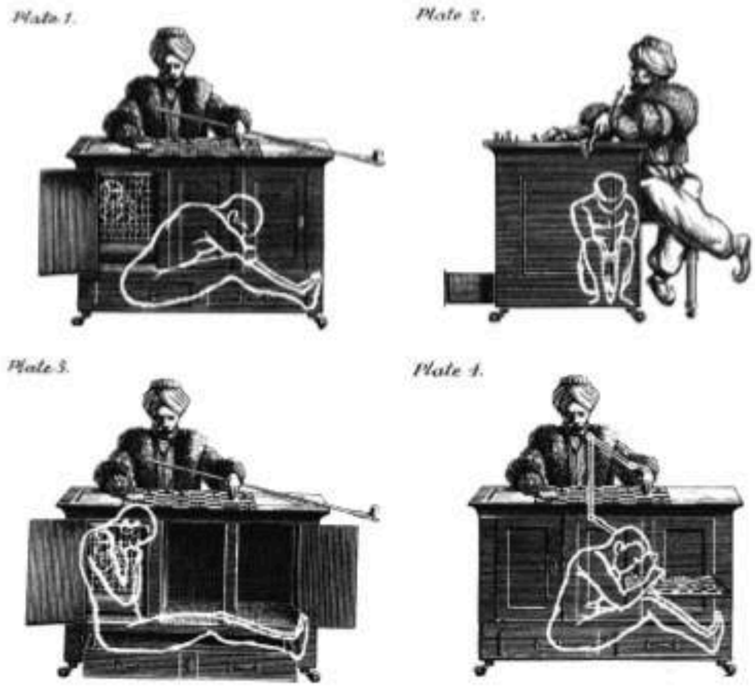

Fig. 3 - The base of its secret was a sliding seat, that can be move back and forth by the operator, Opening and closing various folding partitions (Standage, 2002, p. 198-199).

machinery that was still visible to the audience, would be seen.

(Plate 3) - The operator now had to prepare the cabinet's main compartment for inspection by the audience. As Willis had suspected, the main compartment, which was lined with green baize, was not as simple as it seemed. After sitting back, the operator covered his legs by folding over a lid that formed part of the main compartment's floor; then he concealed his body by closing a door that formed part of the main compartment's floor; then he concealed his body by closing a door that formed part of the main compartment's side. This ensured that the main compartment resembled an almost empty box. By pulling on a string, and hooking its end over a button, the operator then raised into place the small amount of machinery, including wheels, cylinders, and brass quadrants, that was situated in the main compartment. Again, this machinery was a decoy and had no useful function.

(Plate 4) - All of this took a few seconds, however, so the exhibitor did not immediately open the cabinet's front doors. Instead, he opened the drawer and slowly and deliberately removed the chessmen. Have done so, the exhibitor could then open the doors of the main compartment and reveal its almost empty interior. Next, he would open the door at the back of the main compartment and reveals its almost empty interior. Next, he would open the door at the back of the main compartment and introduce a candle, so that the spectators could inspect the main compartment.

The exhibitor then spun the whole contraption around and opened the doors in the back of the Turkish figure to reveal more decoy machinery.

'Cognitive and distributed power' manifested by the Turk

According to Standage (2002 p. 224), Computers are unquestionably the modern descendants of automata: They are '"self-moving machines" in the sense that they blindly follow a preordained series of instructions, but rather than moving physical parts, computers move information. Just like automata, computers operate at the intersection between science, commerce, and entertainment. And they gave rise to an industrial revolution of their own, by extending human mental (as opposed to physical) capacity. The interaction with human agents with the Turk, stimulate an insight that make more explicit the connection with the materiality of objects and their importance for cognition and therefore to interaction in Human Computer Interaction.

During its short history, the field of human computer interaction has been responsible for making our interactions with technology – more specifically with computers –, more friendly and natural and the Turk is used aiming to illustrate some of these aspects, illustrating an alternative model of the mind. The Turk as a model to understand Human computer interaction can suggest a range of possibilities that need to be considered, including a more 'embodied-mind' and 'external' interpretation of cognition, neglecting only a computational approach that was predominant but rather a manifested intelligence in a more broad sense. Some of the observations, questioning the representational paradigm and computation, mainly orchestrated by the (GUI) Graphical User interface paradigm and their limits, which reflects a model which this paper intend to questioning.

One element manifested by the Turk is the materialization of a cooperation between all the elements that was part of the trick. The way that was designed, suggest how Kenpelem had a fully understand of all their constituents parts and elements of the Turk, not only their natural elements but artificial and mechanical harmony manifested eloquently by the machinery to afford the trick and finally the 'user needs'.

What is curious to note is, although Kenpelem wasn't preoccupied or even aware about contemporary HCI discussion, his concern about the machinery in terms of design and applicability, the harmonic interaction between all the elements to afford the trick in a convincible, synchronized manner, generate a device where human 'cognition' is distributed over the people involved (inside and outside of cabinet) and the artefact (the Turk itself). The fraud proposed by Kenpelem, created an structure that promoted the interaction between both elements, either inside and outside of the cabinet, promoted by the interaction resulted by the chessboard, situated not only by the challenger, but for the chess master inside the cabinet, both manipulating pieces of chess and exercise their cognitive capacities in a common ground where both share. Hutchins reminds us "the heavy interaction of internal and external structure suggests that the boundary between inside and outside, or between individual and context, should be softened" (1995, p. 288).

What Kenpelem conceptualized in some sense, is the creation of one artificial environment where embodied intelligence can be manifested and cognition can be distributed across the material and cognitive properties, produced by interactions among their parts. Hutchins (1995a, p. xvi) calls this aspect 'cognitive power' or "the environments of human thinking are not 'natural' environments. They are artificial through and through. Humans create their cognitive powers by creating the environments in which they exercise those powers" (ref).

In harmony with Hutchins idea, The chess-playing machine, inform feedback and eloquent transparency based in its own structural form, generating restrict terrain for human inference: "A good deal of what needs to be done can be inferred from the structure of the artifact, which constrain the organization of action of the task performer by completely eliminating the possibility of certain syntactically incorrect relationships among the terms of the computation". So, as Hutchins said, "Rather than amplify the cognitive abilities of the task performers or act as intelligent agents in interaction with them, these tools transform the task that the person has to do by representing it in a domain where the answer or the path to the solution is apparent" (1995a, p. 155).

In fact, The Turk suggests a solution based on task specialization, restringing the interaction only to their physical structure and materiality. When it comes to desktop computers, what comes to mind is how the complexity and openness of the human project called 'personal computers' became a very ambitious project with higher expectations, but not much can be done without paying a higher cognitive investment to learn and improve ourselves to understand computers and machines.

Nowadays, computers became a viable project, based more on the flexibility and cognitive competence of the user as an acquaintance, than the characteristics and quality promoted by a system made more friendly and accessible by programmer and described technically by designers as 'usability'.

Surely, seems to be impossible to denied that computers based on representational graphic user interface is a model that will be persistent for several years. But what can be observed is how this paradigm is changing, adding to Graphical User Interfaces (GUI), a second level of interaction that open up new possibilities that simulates materiality and operate according to a logic of cause and effect, stimulated by an external force or agent (as gestures like pinching, tapping and technology as accelerometers) which provided a different model of interaction, having the best of the both worlds. This link between this two worlds: one more materialistic and one more digital, became an alternative model to abstract manipulation of representations, which puts together graphic representation and mechanical aspects that seems to be part of one model where most of us seem to be share as part of the experience of 'being in the world' as Heidegger once proclaim.

This condition present also in the Kempelen's Turk Chess-player machine, highlight a fundamental difference between the digital world and the 'real' world. The digital world is intangible and its language use a rhetoric that try to simulate some of these aspect of the real world, making it intuitively congruent with what people assume that is 'real'. For this, buttons seem to be pressed, pages simulate movement, behaviors and sort of resistance that are predictable because they obey fundamental and invariable laws of nature (or at least what became a convention about how this principles is understood). As a result, they are more consistent with the mental model of the humans or users. Thats why HCI became a discipline that is mostly about anticipation and prediction, which creates a model of reverse engineering to understand the human mind. The Turk as a model, elucidate exactly this point. The Turk highlights this enactive approach, which is the central claim against the way that traditional information-processor psychology understand perception as something that arises entirely internal of the individual. The enactive approach clarify that perception not only depends on, but is constituted by, our possession of this sort of embodied and embedded sensorimotor knowledge, crucial to understand cognition.

"Having failed to notice that the central metaphor of the physical-symbol-system hypothesis captured the properties of a sociocultural system rather than those of an individual mind, AI and information-processing psychology proposed some radical conceptual surgery for the modeled human. The brain was removed and replaced with a computer. This surgery was a success. However, there was an apparently unintended side effect: the hands, the eyes, the ears, the nose, the mouth, and the emotions all fell away when the brain was replaced by a computer" (1995a, pg. 363).

The Turk, determined by the materiality of its components, and by the restricted domain of the chessboard and direct manipulation, offers to the 'user' simply interactivity based in the 'real world interaction' building space not only for the manifestation of our mind through this machine, but also, to manifestation of our sensorimotor knowledge and agency, promoting perceptual experience. Hutchins himself argued that perceptual experience depends on sensorimotor contingency. A causal dependence of experience on action: "Perceptual experience, according to the enactive approach, is an activity of exploring the environment drawing on knowledge of sensorimotor dependencies and thought" (1995a, pg. 228).

The Turk, as a tool, has this quality to promote this reconciliation where 'The computational constraints of the problem have been built into its physical structure', as well as Hutchins understand cognition. Not just a simulation of the world (as for instance, the Graphical User Interface dominant paradigm), but paraphrasing Edwin Holts, using 'the world itself as its best representation' and therefore, central for cognitive processes.

Concluding remarks

The results that was being developed so far, is mainly an attempt to related these two aspects: Early automatons and Human computer interaction, and in some respect, what kind of eloquence that can be found in the Turk machine to rethink Human Computer Interaction.

Maybe this idea is not something new. Distributed, embodied and enacted notion of cognition has been considered for a while in scientific community. The philosophical idea that implies a new concept of mind to understand cognition and conscious has been used to reframe several disciplines and in this research to reframe HCI.

Although, Human Computer Interaction has been achieving a considerable commercial success, empowered users to do their own work and activities using this sophisticated piece of engineering and promoting such a technological inclusion, much of what is known about Human-Computer-Interaction is based on the archaic notion of computation within cognitive science, which maintained that people behave as information processors and that the process of thinking is very similar to the process of computing. All the substantial changes in HCI is contaminated by such idea, which transformed HCI in a science of incrementalism, offering reasonable resistance to their users.

Automatons in the 18th century, suggests to be part of the human desire to have machine to serve as entertainment, for joy and also enlightment, as well as a hope to replace human labor. Nowadays, the contemporary computer is the machine that carries the hope to relieve humanity of the labor. However, what is interesting to notice is in that relationship, ironically, have turned the users in 'authentic automatons'.

If computers should be doing this the conclusion is: there is something wrong with HCI. Seems to be clear that computers can replace or support humans in some activities – sometimes, even more efficiently –, but for more sophisticated tasks, it requires more dynamic processes and complexity than the computational models can sustain. The Turk automaton bring to the surface some points where embodied cognition emerges by the materiality of its components, highlighting exactly crucial points where in Human Computer Interaction, users are still struggling, winding up the clock.

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#9.ART

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DE ARTE E TECNOLOGIA

SISTEMAS COMPLEXOS ARTIFICIAIS, NATURAIS E MISTOS

#9

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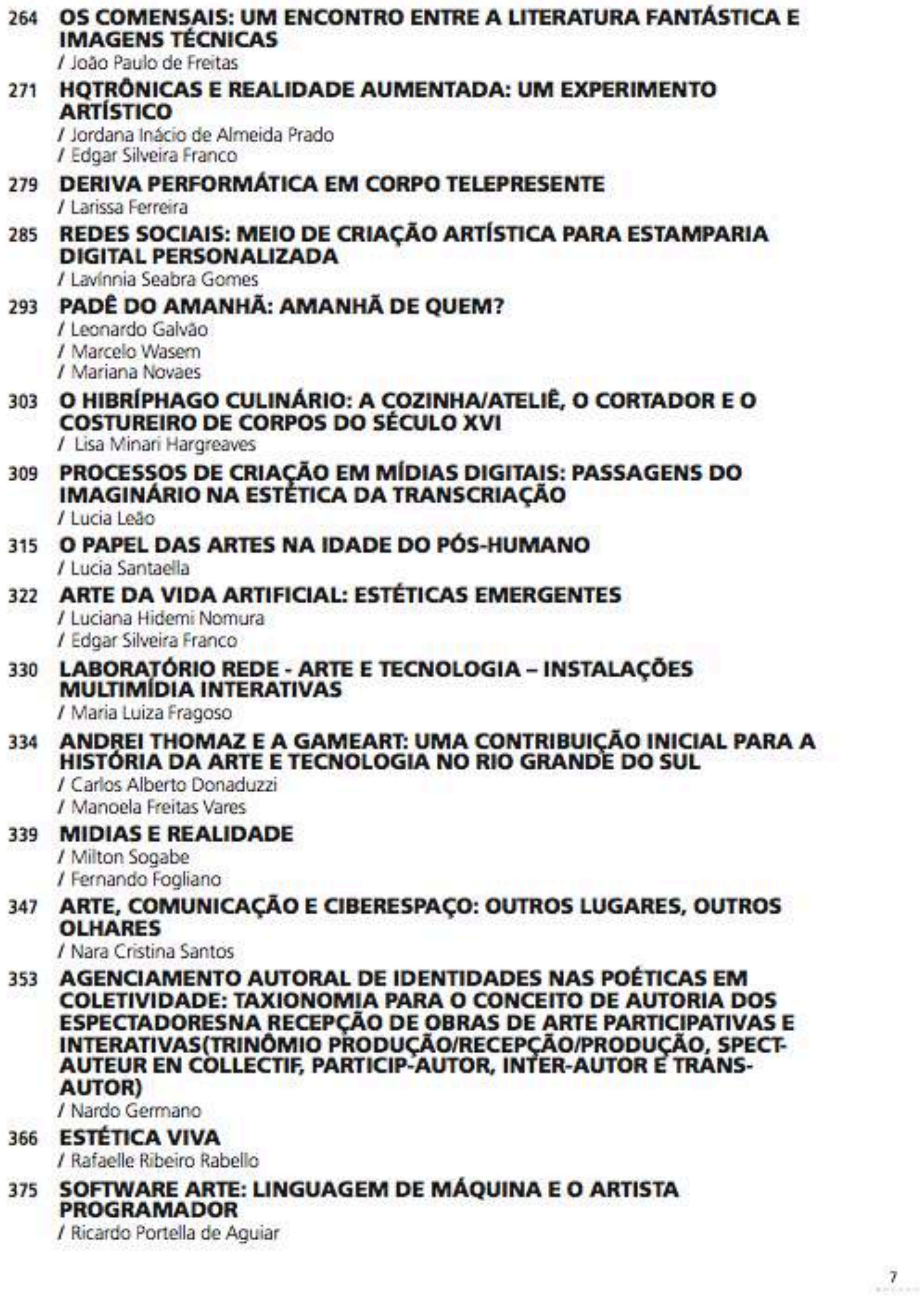
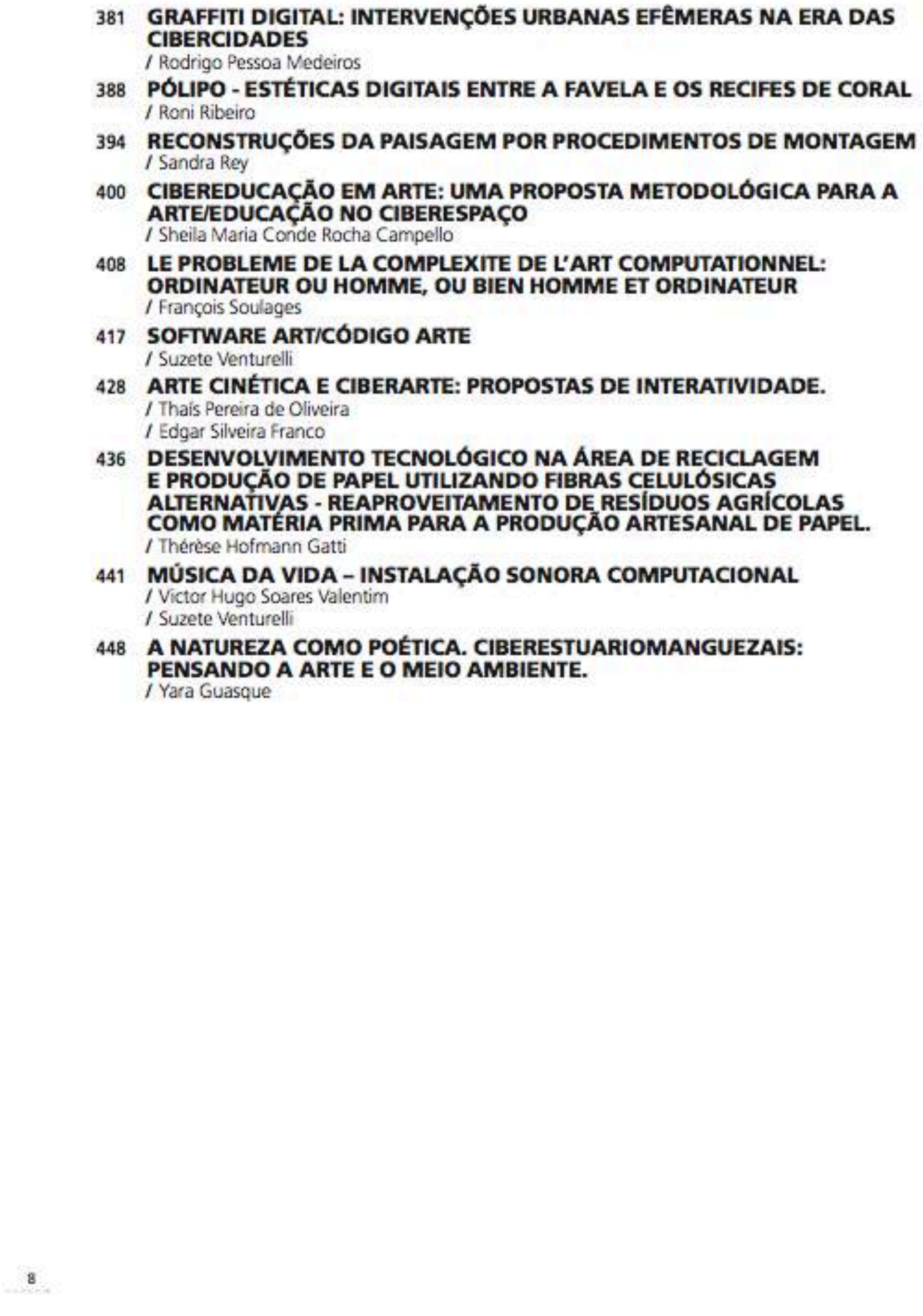
SUMÁRIO





REALIDADES, IMAGENS E VIRTUALIDADE - TERMINOLOGIA TAXONÔMICA BASEADA NA EXPERIÊNCIA DO USUÁRIO

/ Cleomar Rocha[1]
/ Marcio Rocha[2]

Resumo

O artigo problematiza a terminologia e definição dos termos realidade virtual, realidade mista, realidade aumentada e virtualidade aumentada, tendo a experiência sensível como base de discussão. Faz uso da teoria da objetivação para defender que o uso, ainda que inapropriado concei-tualmente, se resolve pela convenção estabelecida, mantendo-se no nível semântico.

Palavras-chaves: Realidade Virtual, Realidade Mista, Realidade Aumentada, Virtualidade Aumentada.

Introdução

Em 1994, Paul Milgram e Fumio Koshino, cientistas da computação da Universidade de Toronto, já demonstravam preocupação com uma taxonomia adequada para as tecnologias relacionadas que envolvem a fusão dos mundos "real" e "virtual" em um *continuum* virtual onde tais elementos se conectam, chamadas por ele Realidade Mista (RM), além das tecnologias derivadas, como a Virtualidade Aumentada (VA) e a Realidade Aumentada (RA), consideradas por ele como um subconjunto específico. Com o crescente interesse da comunidade científica em suas aplicações e a popularização através de ações específicas da propaganda e da mídia, essa classificação se torna cada vez mais necessária.

Dentro as tecnologias que propõem a fusão entre o mundo natural e o virtual, provavelmente o mais conhecido deles é a Realidade Aumentada (RA). Na realidade aumentada, a exibição de um ambiente real é transformada com a inserção de objetos, elementos gráficos ou dados computacionais, e que portanto, atualizam a nossa visão através da atualização proporcionada pela virtualidade desses objetos, sobrepostos a realidade.

Segundo os autores (MILGRAM E KOSHINO, 1994) é possível observar seis classes distintas de ambientes de visualização híbrida, dentro da Realidade Mista. Há portanto, por parte dos pesquisadores, uma tentativa de distinguir essas classes em função de se tratar de uma visualização por vídeo, baseado em computação gráfica, se o mundo real é visto diretamente ou através de algum tipo de dispositivo eletrônico de visualização, se o espectador sente-se parte do mundo, ou se o observa de fora para dentro. Distinções que levam a condições diferentes entre as seis classes identificadas, demonstrando assim a necessidade de uma eficiente taxonomia, ou quadro classificatório, segundo a qual as diferenças essenciais possam ser identificadas.

Padrões taxionômicos propostos por Milgran e Kishino

Conforme Paul Milgram e Kishino (1994), a meslca ou mistura dos campos visuais virtuais e do mundo natural, denominada de Realidade Mista (RM), se organiza em duas grandes

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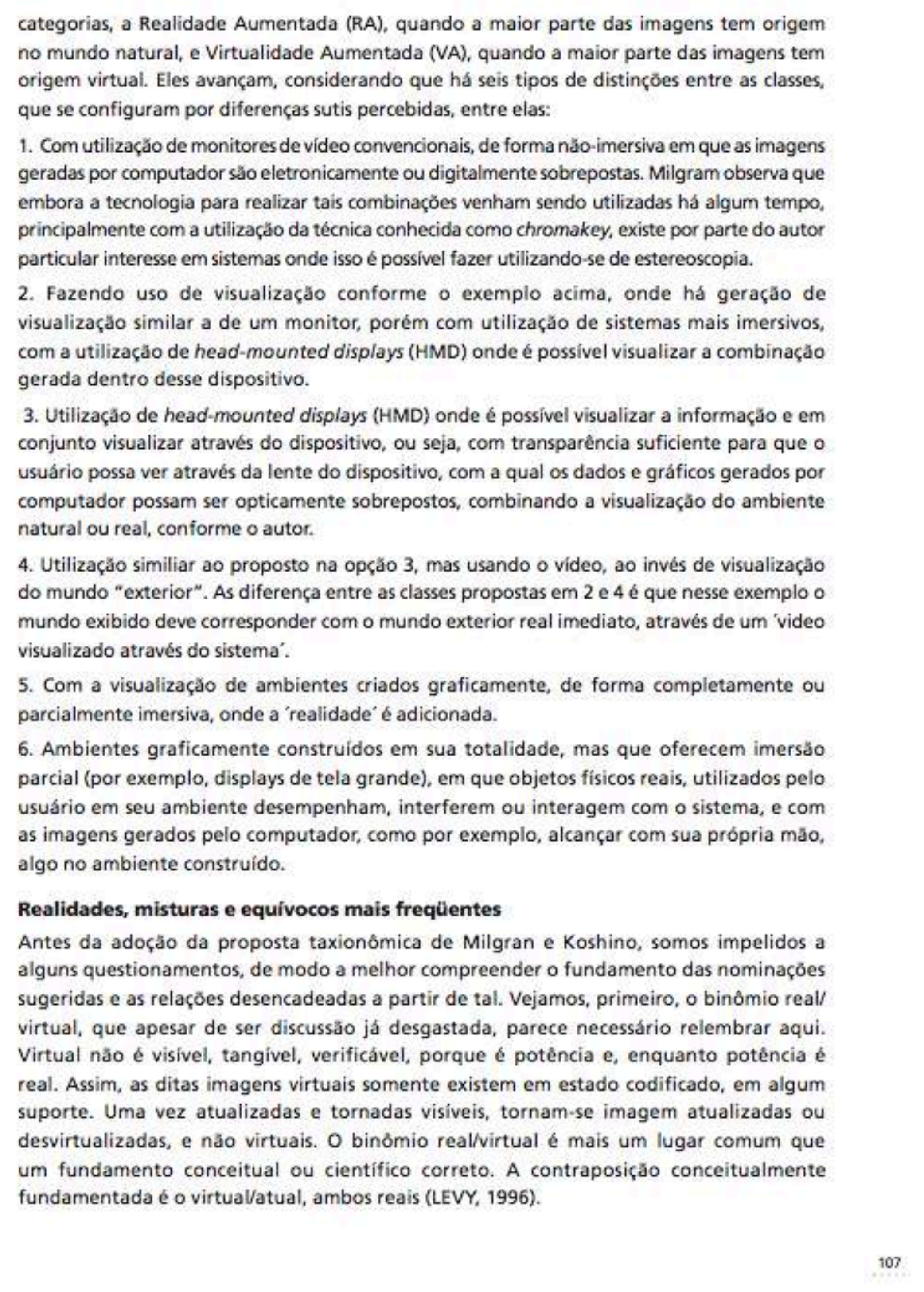

categorias, a Realidade Aumentada (RA), quando a maior parte das imagens tem origem no mundo natural, e Virtualidade Aumentada (VA), quando a maior parte das imagens tem origem virtual. Eles avançam, considerando que há seis tipos de distinções entre as classes, que se configuram por diferenças sutis percebidas, entre elas:

1. Com utilização de monitores de vídeo convencionais, de forma não-imersiva em que as imagens geradas por computador são eletronicamente ou digitalmente sobrepostas. Milgram observa que embora a tecnologia para realizar tais combinações venham sendo utilizadas há algum tempo, principalmente com a utilização da técnica conhecida como *chromakey*, existe por parte do autor particular interesse em sistemas onde isso é possível fazer utilizando-se de estereoscopia.

2. Fazendo uso de visualização conforme o exemplo acima, onde há geração de visualização similar a de um monitor, porém com utilização de sistemas mais imersivos, com a utilização de *head-mounted displays* (HMD) onde é possível visualizar a combinação gerada dentro desse dispositivo.

3. Utilização de *head-mounted displays* (HMD) onde é possível visualizar a informação e em conjunto visualizar através do dispositivo, ou seja, com transparência suficiente para que o usuário possa ver através da lente do dispositivo, com a qual os dados e gráficos gerados por computador possam ser opticamente sobrepostos, combinando a visualização do ambiente natural ou real, conforme o autor.

4. Utilização similiar ao proposto na opção 3, mas usando o vídeo, ao invés de visualização do mundo "exterior". As diferença entre as classes propostas em 2 e 4 é que nesse exemplo o mundo exibido deve corresponder com o mundo exterior real imediato, através de um ´video visualizado através do sistema´.

5. Com a visualização de ambientes criados graficamente, de forma completamente ou parcialmente imersiva, onde a ´realidade´ é adicionada.

6. Ambientes graficamente construídos em sua totalidade, mas que oferecem imersão parcial (por exemplo, displays de tela grande), em que objetos físicos reais, utilizados pelo usuário em seu ambiente desempenham, interferem ou interagem com o sistema, e com as imagens gerados pelo computador, como por exemplo, alcançar com sua própria mão, algo no ambiente construído.

Realidades, misturas e equívocos mais freqüentes

Antes da adoção da proposta taxionômica de Milgran e Koshino, somos impelidos a alguns questionamentos, de modo a melhor compreender o fundamento das nominações sugeridas e as relações desencadeadas a partir de tal. Vejamos, primeiro, o binômio real/virtual, que apesar de ser discussão já desgastada, parece necessário relembrar aqui. Virtual não é visível, tangível, verificável, porque é potência e, enquanto potência é real. Assim, as ditas imagens virtuais somente existem em estado codificado, em algum suporte. Uma vez atualizadas e tornadas visíveis, tornam-se imagem atualizadas ou desvirtualizadas, e não virtuais. O binômio real/virtual é mais um lugar comum que um fundamento conceitual ou científico correto. A contraposição conceitualmente fundamentada é o virtual/atual, ambos reais (LEVY, 1996).

Admitindo-se, contudo, que a sugestão real/virtual quer dizer natural/sintético, referindo o primeiro termo às imagens do mundo natural que alcançam o olho ou as lentes de dispositivos fotográficos e o segundo termo as imagens geradas a partir de cálculos numéricos computacionais, denominadas sintéticas, encontramos alguns outros pontos de necessária discussão.

Santaella e Nöth (1997) nos apresentam uma classificação das imagens a partir de seu método de geração. Os autores denominam pré-fotográficas as imagens geradas por alguém, como um pintor, um desenhista. A imagem é uma produção humana.

> Em síntese, no primeiro paradigma (pré-fotográfico) encontram-se processos *artesanais de criação* da imagem (...) A característica básica do modo de produção artesanal está na realidade matérica das imagens (...) Nessa imagem instauradora, fundem-se, num gesto indissociável, o sujeito que a cria, o objeto criado e a fonte de criação" (163, 164)

Às imagens produzidas por máquinas sensíveis à luz, como câmeras fotográficas ou videográficas, os autores denominam imagens fotográficas, aqueles geradas pela exposição de matéria fotossensível diretamente a luz do mundo natural. São imagens geradas tecnicamente, em "... *processos automáticos* de captação da imagem (idem, 1997, 163).

Finalmente, imagens geradas por computadores a partir de cálculos matemáticos, em processos de síntese numérica são chamadas de imagens pós-fotográficas: "... *processos matemáticos* de geração da imagem.– (ibidem, 1997, 163).

Sua referência é o código digital, e sua existência é virtual quando não está sendo apresentada em algum dispositivo de visualização, como uma interface gráfica. Assim, enquanto código binário em um HD ou *pendrive*, sua existência é virtual. Em um monitor a imagem é atualizada, possibilitando sua visualização.

Tendo esta classificação em mente, voltemos a Milgram e Koshino, para entendermos o que ele denomina de Realidade Misturada. Como visto, o termo refere-se a mistura de imagens do mundo natural, visualizadas diretamente ou a partir de dispositivos de visualização, sugerindo imagens fotográficas, e imagens pós-fotográficas, aquelas geradas a partir de síntese numérica (opções 1, 2 e 4) . É possível entender, quando os autores falam em sobreposição, que a mistura é mais uma visualização conjunta que uma mistura, de fato. A sobreposição sugere que algo está sobre outro elemento, e não necessariamente se misturando a ele. São camadas sobrepostas, mas ainda camadas. Certamente que ao referir-se a visualização, a sobreposição sugere uma mistura, visto que a percepção visual se dá em relação ao todo e desta compreensão surgem vários estudos de ilusão óptica, notadamente as de orientação a distorção da imagem.

À parte desta possibilidade, será preciso aceitar que, se a imagem do mundo natural é captada por um dispositivo tecnológico, como uma câmera, o que se vê de fato não é o mundo natural, mas uma imagem dele. Trata-se de um signo visual e não da coisa que ele substitui ou se refere, o mundo natural. A imagem apresentada pela câmera não é o mundo natural, mas uma imagem fotográfica. Com isto o que o dispositivo constrói é uma sobreposição de imagens, a pós-fotográfica sobreposta à fotográfica, ou signo sobre signo, e não exatamente uma mistura de dados computacionais com o mundo natural, como se é levado a aceitar. A diferença de recursos similares, como o *Chromakey*, passa a ser o método tecnológico de geração das imagens sobrepostas, e não o efeito visual a que se chega. Os quadros apresentados em telejornais, que dividem a tela com os apresentadores são igualmente recursos de sobreposição de imagens pós-fotográficas com as fotográficas. Não há, aqui, grande alteração que não a pós-massividade da mídia digital. Quanto ao efeito, trata-se do mesmo resultado visual, ainda que com métodos distintos, resguardadas as diferenças de relação das imagens pós-fotográficas apresentadas, visto que no telejornal é uma informação pronta, possível, enquanto que no dispositivo de realidade virtual a imagem não é um possível, mas virtual, a não ser quando atualizada e vista, quando é imagem sintética.

Caso, contudo, o observador esteja vendo de fato o mundo natural através de algum artefato translúcido, sobre o qual são projetados novos dados de origem sintética, mesclando-se, no olhar, as informações visuais (opção3), certamente será preciso aceitar que não há mistura alguma, mas o arranjo realizado pelo olho, não pela objetividade do mundo. Assim, não terá diferente de o observador ver um adesivo colado na vidraça, através da qual ele enxerga uma rua, e a mistura requerida. Certamente a distinção está na qualidade da imagem projetada no suporte translúcido, como movimentos e relação estabelecida como a imagem do mundo natural vista, mas certamente ao retirar o anteparo de frente dos olhos, poder-se-á enxergar ambas as imagens, sem qualquer ilusão de mistura, o que não ocorre no primeiro caso, por tratar-se de uma imagem sobreposta a outra.

Não se pretende, com isto, negar as possibilidades trazidas por estes dispositivos, que certamente concorrem para grandes inovações em suas aplicações, em diversos níveis. Contudo, deve-se acomodar os conceitos e aceitar as nominações no contexto da linguagem, não se referindo a elas em sentido denotativo. Os termos propostos por Milgran e Koshino e alardeados nos vários campos de conhecimento mantém sua relação semântica precisa, embora conceitualmente careçam de maior precisão.

Conclusão

As linguagens são ordenações arbitrárias, como todo signo, lingüístico ou não. Os aspectos semânticos, considerados como o vínculo estabelecido entre representamem e referente, oscilam conforme o contexto e a enunciação. As variações semânticas são uma constante, de tal modo que a própria semântica se ocupa desta variação, a despeito do termo ressignificação, em voga atualmente. Como toda ordenação arbitrária, o sentido pode até ser questionado, mas a arbitrariedade conduz ao uso, de forma que o uso determina mais que o conceito, por força da dinamicidade semântica, já referida. Dizer que o determinado termo não se aplica a algo pode até proceder conceitualmente, mas o elemento determinante será sempre seu uso por uma comunidade lingüística, por mais que seja improcedente etimologicamente ou conceitualmente. A semântica se estabelece pelo uso, pelos interpretantes em um contexto pragmático.

Posto isto, e admitindo-se toda a nominação defendida por Milgran e Koshino, reitera-se que sua concepção é sustentada por uma orientação conotativa, em franca derivação da expressão Realidade Virtual, conceitualmente incorreta (CADOZ, 2005), mas mantida semanticamente. De modo similar termos como imagem virtual continuam em voga, embora inexistente em seus conceitos *strictos*. E em sendo assim, uma gama de termos e expressões careceriam de melhor definição conceitual. Mas o uso não está escravo do conceito, mas de si mesmo, no que tais termos e expressões, à parte de seus conceitos, são mantidos em uso e expressam o pensamento de quem os utiliza, de modo que o exercício hermenêutico, antes de considerar o conceito, deve se nortear pela pragmática e pela semântica, que orbitam com maior fidelidade o espírito do pensamento.

Ainda que os termos propostos por Milgran e Koshono sejam conceitualmente questionáveis, seu uso é fato, restando tão somente pontuar suas relações em contextos conotativos, como este artigo tentou esclarecer.

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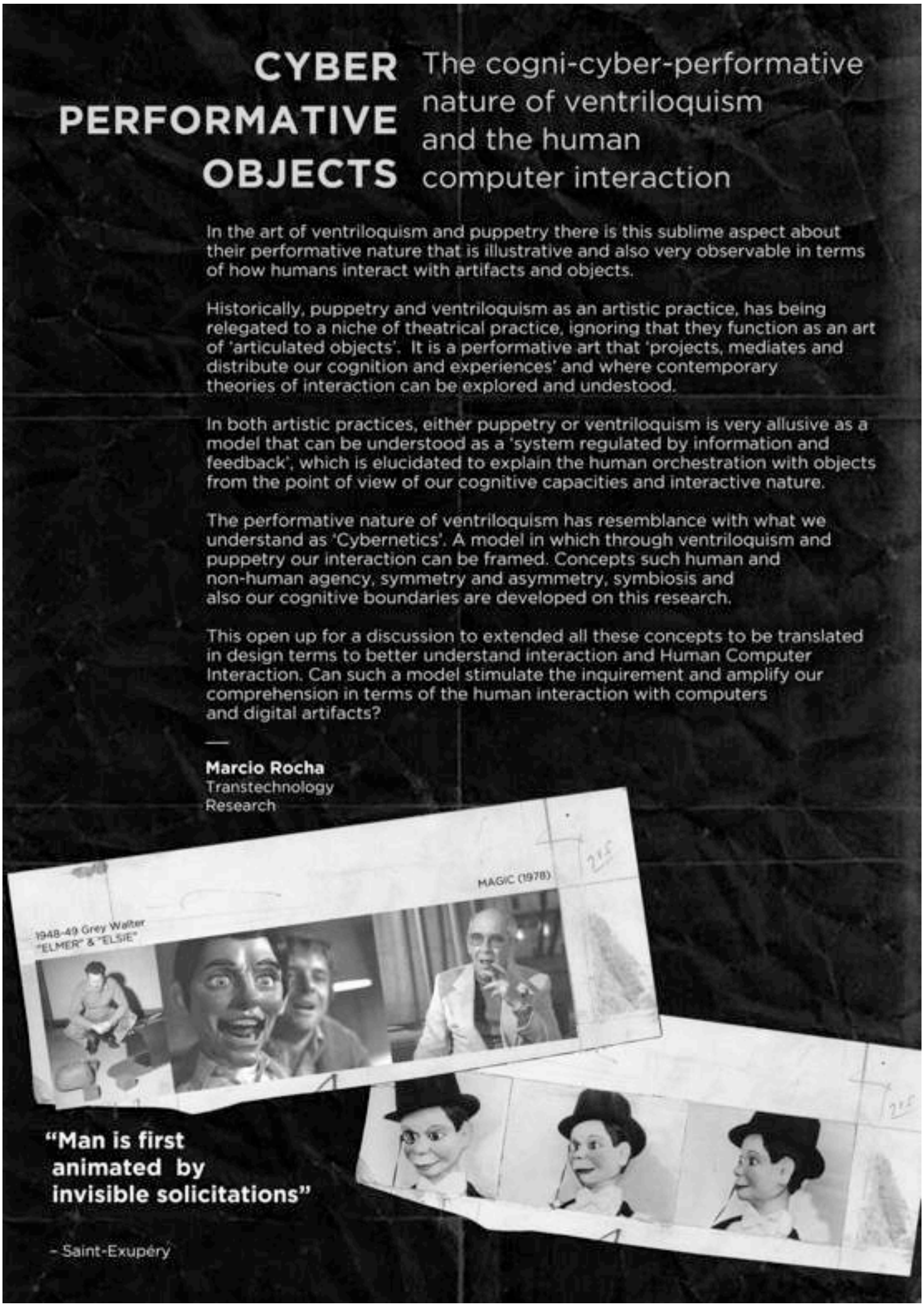
Mestre em Gestão do Patrimonio Cultural (PUC-GO). Bacharel em Artes Visuais com habilitação em Design Gráfico (UFG) Professor do Curso de Artes Visuais no Bacharelado em Design Gráfico da FAV/UFG na área de Midias Interativas. Designer, professor e pesquisador.

Posters presentation



CYBER PERFORMATIVE OBJECTS

The cogni-cyber-performative nature of ventriloquism and the human computer interaction

In the art of ventriloquism and puppetry there is this sublime aspect about their performative nature that is illustrative and also very observable in terms of how humans interact with artifacts and objects.

Historically, puppetry and ventriloquism as an artistic practice, has being relegated to a niche of theatrical practice, ignoring that they function as an art of 'articulated objects'. It is a performative art that 'projects, mediates and distribute our cognition and experiences' and where contemporary theories of interaction can be explored and undestood.

In both artistic practices, either puppetry or ventriloquism is very allusive as a model that can be understood as a 'system regulated by information and feedback', which is elucidated to explain the human orchestration with objects from the point of view of our cognitive capacities and interactive nature.

The performative nature of ventriloquism has resemblance with what we understand as 'Cybernetics'. A model in which through ventriloquism and puppetry our interaction can be framed. Concepts such human and non-human agency, symmetry and asymmetry, symbiosis and also our cognitive boundaries are developed on this research.

This open up for a discussion to extended all these concepts to be translated in design terms to better understand interaction and Human Computer Interaction. Can such a model stimulate the inquirement and amplify our comprehension in terms of the human interaction with computers and digital artifacts?

—

Marcio Rocha
Transtechnology
Research

"Man is first animated by invisible solicitations"

– Saint-Exupery

Rocha, M. (2014). ‘Cyber performative. [Poster presentation].Cognition Institute Conference. Plymouth University, Plymouth, UK.

Aesthetics of Access

Claudy Op den Kamp

Notions on a radical moving image archive practice as a problematic

Amanda Egbe

From early automata to the contemporary intelligent being

Marcio Rocha

Infra-mince, Laughter & Cybernetics - Exploring the Curatorial as Creative Act

Edith Doove

The optical illusion of third dimension in the graphical representation and the virtual projections

Madalena Grimaldi

An enacted choreography between perceiver and perceived

Martyn Woodward

The hollow body and the mouth of the monster

Rita Cachao

From graffite to interactive urban cyberintervention

Claudia Loch

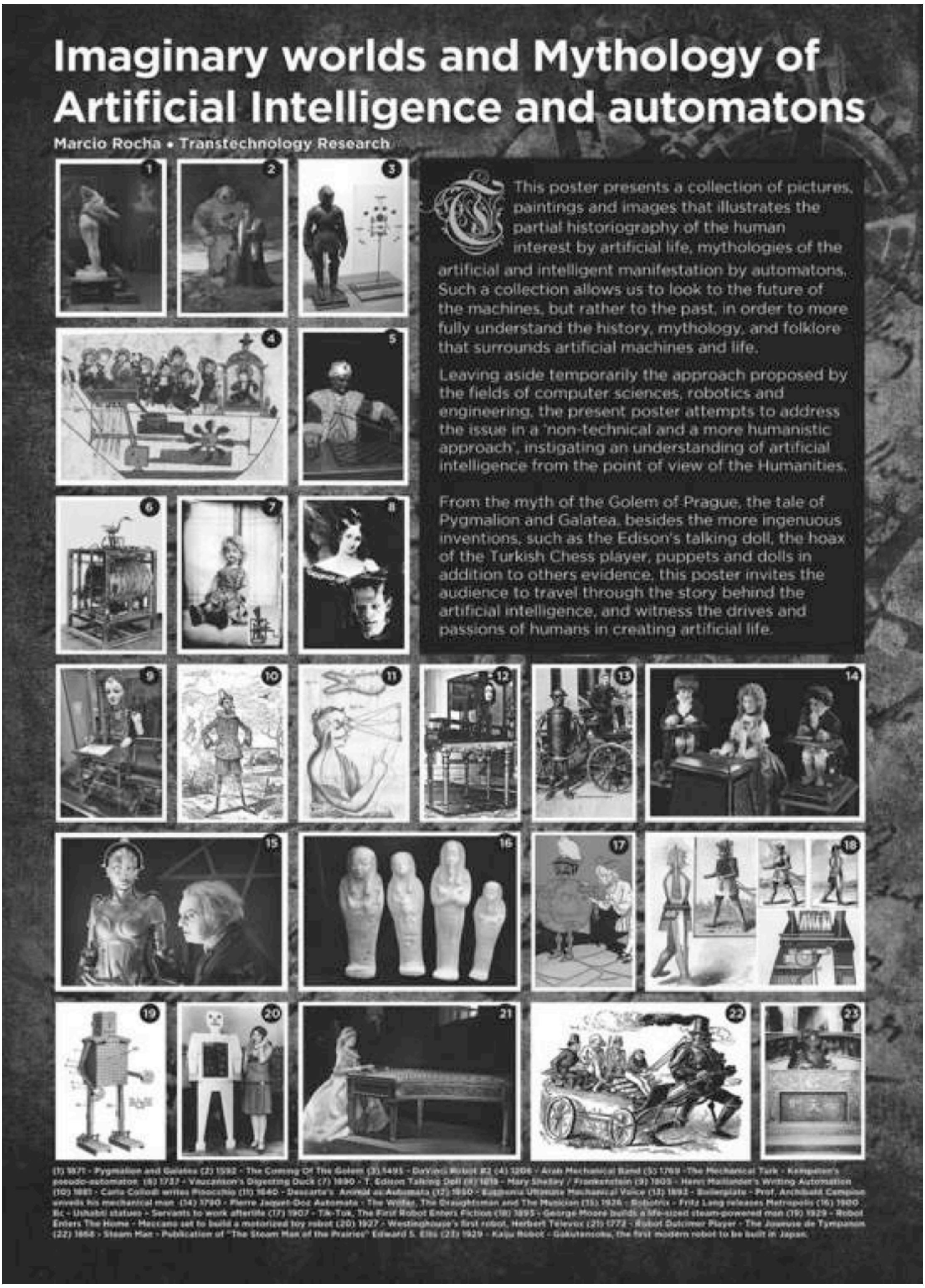
transtechnology research

Transtechnology Research is a transdisciplinary research group situated in the Faculty of Arts. Its constituency is drawn from historians, philosophers, anthropologists, artists and designers and is led from a historical and theoretical perspective with the objective of understanding science and technology as a manifestation of a range of human desires and cultural imperatives.

Its aim is to provide a doctoral and post-doctoral environment for researchers who need to undertake academic research informed by their own and others creative practice. Its overarching research project concerns the philosophical aspects of science and technology and the history of popular arts. The key objective is to understand the significance of creative agency in the process of technology acquiring meaning both before, and after, it enters into the public domain.

Using a range of practice and theory based methods, the group is concerned to make apparent evidence of human desire and cultural imperatives as they are manifested in the way that science and technology is practiced, innovated by entrepreneurs and interpreted by its users.

Rocha, M. (2013). ‘For early automaton, to the contemporary intelligence being. [Poster presentation].Cognition Institute Conference. Plymouth University, Plymouth, UK.



Imaginary worlds and Mythology of Artificial Intelligence and automatons

Marcio Rocha • Transtechnology Research

This poster presents a collection of pictures, paintings and images that illustrates the partial historiography of the human interest by artificial life, mythologies of the artificial and intelligent manifestation by automatons. Such a collection allows us to look to the future of the machines, but rather to the past, in order to more fully understand the history, mythology, and folklore that surrounds artificial machines and life.

Leaving aside temporarily the approach proposed by the fields of computer sciences, robotics and engineering, the present poster attempts to address the issue in a 'non-technical and a more humanistic approach', instigating an understanding of artificial intelligence from the point of view of the Humanities.

From the myth of the Golem of Prague, the tale of Pygmalion and Galatea, besides the more ingenuous inventions, such as the Edison's talking doll, the hoax of the Turkish Chess player, puppets and dolls in addition to others evidence, this poster invites the audience to travel through the story behind the artificial intelligence, and witness the drives and passions of humans in creating artificial life.

(1) 1871 - Pygmalion and Galatea (2) 1592 - The Coming Of The Golem (3) 1495 - DaVinci Robot #2 (4) 1206 - Arab Mechanical Band (5) 1769 -The Mechanical Turk - Kempelen's pseudo-automaton (6) 1737 - Vaucanson's Digesting Duck (7) 1890 - T. Edison Talking Doll (8) 1818 - Mary Shelley / Frankenstein (9) 1805 - Henri Maillardet's Writing Automation (10) 1881 - Carlo Collodi writes Pinocchio (11) 1640 - Descarte's 'Animal as Automata (12) 1850 - Euphonia Ultimate Mechanical Voice (13) 1893 - Boilerplate - Prof. Archibald Campion unveils his mechanical man (14) 1790 - Pierre Jaquet-Droz Automata - The Writer, The Draughtsman and The Musician (15) 1926 - Robotrix - Fritz Lang releases Metropolis (16) 1900 Bc - Ushabti statues - Servants to work afterlife (17) 1907 - Tik-Tok, The First Robot Enters Fiction (18) 1895 - George Moore builds a life-sized steam-powered man (19) 1929 - Robot Enters The Home - Meccano set to build a motorized toy robot (20) 1927 - Westinghouse's first robot, Herbert Televox (21) 1772 - Robot Dulcimer Player - The Joueuse de Tympanon (22) 1868 - Steam Man - Publication of "The Steam Man of the Prairies" Edward S. Ellis (23) 1929 - Kaiju Robot - Gakutensoku, the first modern robot to be built in Japan.

Rocha, M. (2013). 'Imaginary worlds and mythology of Artificial Intelligence and automatons. [Poster presentation]. Poster presentation for Pos Graduate Society Conference – University of Plymouth, UK.

POSTER DESCRIPTION

Imaginary worlds and mythology of Artificial intelligence and automatons

Marcio Rocha

Abstract

This poster presents a collection of pictures, paintings and images that illustrates the partial historiography of the human interest by artificial life, mythologies of the artificial and intelligent manifestation by automatons. Such a collection allows us to look to the future of the machines, but rather to the past, in order to more fully understand the history, mythology, and folklore that surrounds artificial machines and life.

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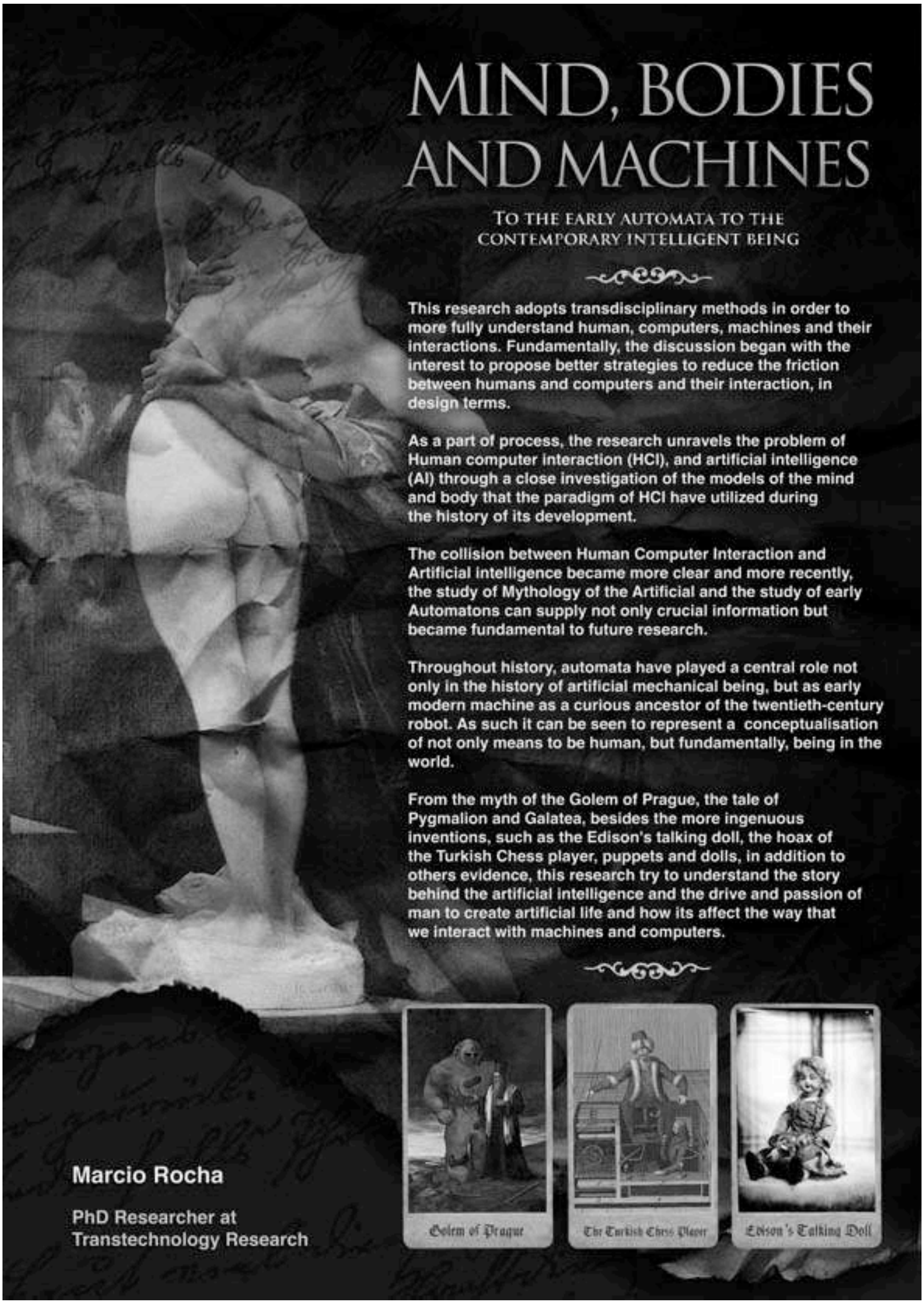


MIND, BODIES AND MACHINES

TO THE EARLY AUTOMATA TO THE CONTEMPORARY INTELLIGENT BEING

* * *

This research adopts transdisciplinary methods in order to more fully understand human, computers, machines and their interactions. Fundamentally, the discussion began with the interest to propose better strategies to reduce the friction between humans and computers and their interaction, in design terms.

As a part of process, the research unravels the problem of Human computer interaction (HCI), and artificial intelligence (AI) through a close investigation of the models of the mind and body that the paradigm of HCI have utilized during the history of its development.

The collision between Human Computer Interaction and Artificial intelligence became more clear and more recently, the study of Mythology of the Artificial and the study of early Automatons can supply not only crucial information but became fundamental to future research.

Throughout history, automata have played a central role not only in the history of artificial mechanical being, but as early modern machine as a curious ancestor of the twentieth-century robot. As such it can be seen to represent a conceptualisation of not only means to be human, but fundamentally, being in the world.

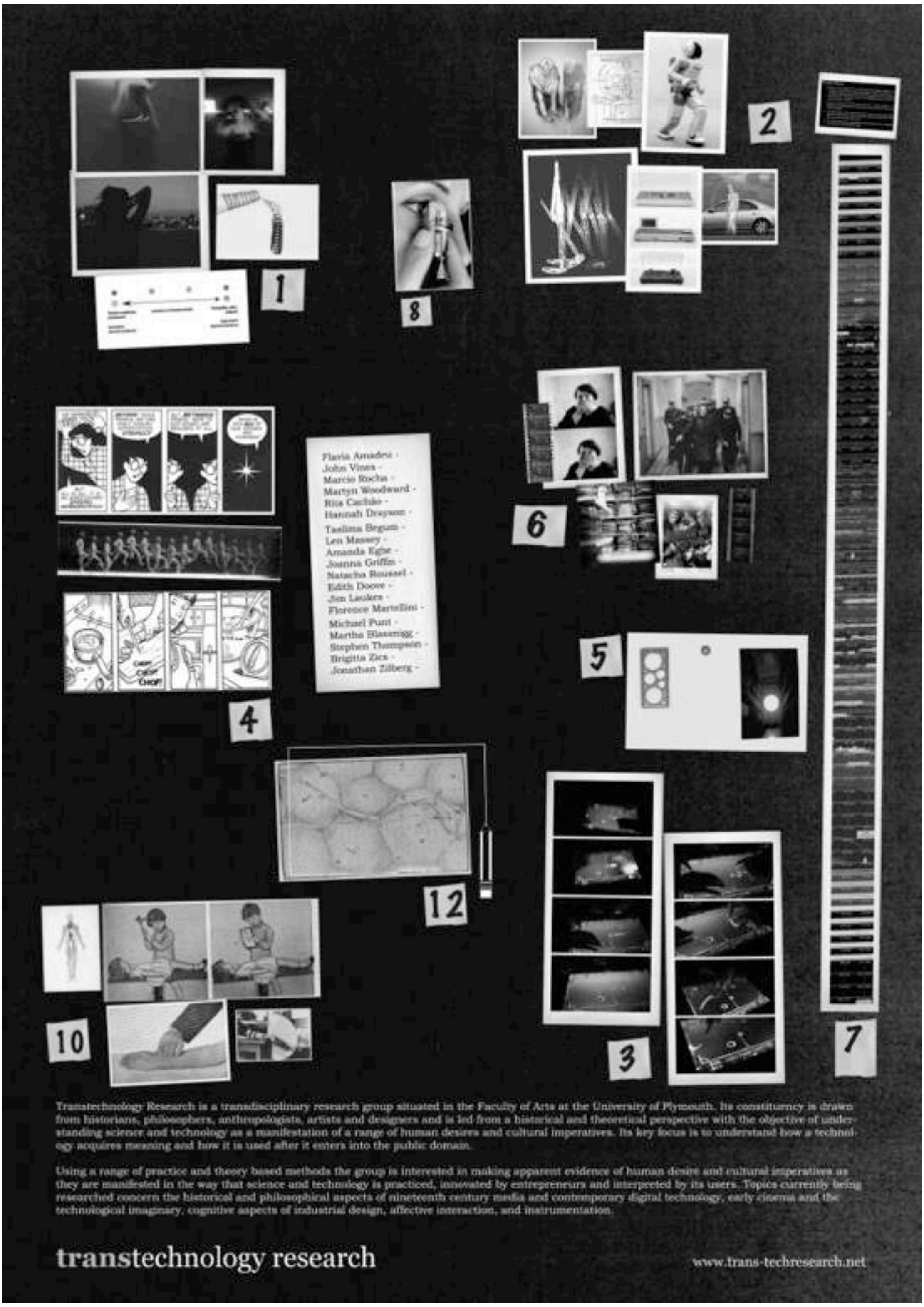
From the myth of the Golem of Prague, the tale of Pygmalion and Galatea, besides the more ingenuous inventions, such as the Edison's talking doll, the hoax of the Turkish Chess player, puppets and dolls, in addition to others evidence, this research try to understand the story behind the artificial intelligence and the drive and passion of man to create artificial life and how its affect the way that we interact with machines and computers.

* * *

Marcio Rocha

**PhD Researcher at
Transtechnology Research**

Rocha, M. (2013). ‘Mind, Bodies and Machines - To the early automata to the contemporary intelligent being’ [Poster presentation]. Lure of the New, Cognition Institute Conference. Plymouth University, Plymouth, UK. 21st March.



Flavia Amadeu -
John Vines -
Marcio Rocha -
Martyn Woodward -
Rita Cachão -
Hannah Drayson -
Taslima Begum -
Len Massey -
Amanda Egbe -
Joanna Griffin -
Natacha Roussel -
Edith Doove -
Jim Laukers -
Florence Martellini -
Michael Punt -
Martha Blassnigg -
Stephen Thompson -
Brigitta Zics -
Jonathan Zilberg -

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Using a range of practice and theory based methods the group is interested in making apparent evidence of human desire and cultural imperatives as they are manifested in the way that science and technology is practiced, innovated by entrepreneurs and interpreted by its users. Topics currently being researched concern the historical and philosophical aspects of nineteenth century media and contemporary digital technology, early cinema and the technological imaginary, cognitive aspects of industrial design, affective interaction, and instrumentation.

transtechnology research

www.trans-techresearch.net

Rocha, M. and Woodward, M. (2013) ‘Transtechnology Research’ [Poster design for collective research presentation]. Lure of the New, Cognition Institute launch and conference, University of Plymouth, Plymouth, UK. 21st March.