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GESTALT BIOMETRICS AND THEIR APPLICATIONS; INSTRUMENTATION, OBJECTIVITY AND POETICS

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Gestalt Biometrics and their Applications;

Instrumentation, objectivity and poetics.

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Gestalt Biometrics and their Applications;

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Abstract

This thesis is about the relationship between human bodies and instrumental technologies that can be use to measure them. It adopts the position that instruments are technological structures that evoke and manifest particular phenomena of embodied life. However, through their history of association and use in the sciences and scientific medicine, instruments tend to be attached to a particular ontology, that of mechanical objectivity.

Embarking from research into the artistic uses of physiological sensor technology in creative practices such as performance and installation art, this thesis asks whether it is possible to use instruments in a way that departs from their association with scientific objectivity. Drawing on philosophers who have developed an understanding of the relationship of instrumental technologies and human bodies as co-constructive, it explores how this model of con-construction might be understood to offer an alternative ontology for understanding the use of instruments in practices outside of science and scientific medicine. The project is therefore suggestive of degrees of freedom and flexibility that are open to exploitation by creative practices in the realm of instrumentation as an alternative to orthodox rationalisations of the value of scientific equipment as authentic, revealing and objective.

The major contribution of the thesis is that transfers and synthesises arguments and evidence from the history and philosophy of sciences that serve to demonstrate how the instrumental measurement of human bodies can be considered to be a form of creative practice. It assembles a position based on the work of thinkers from a number of disciplines, particularly philosophy of science, technology, and the medical humanities. These offer examples of ontological frameworks within which the difference between the realm of the instrumental, material, biological, and the objective, and the phenomenal, meaningful and subjective, might be collapsed. Doing this, the thesis sheds light on how physical devices might enter into the interplay of making, mattering and objectifying the immaterial, a realm that it might be considered the role of artists to manifest.

Drawing on contemporary, and secondary, accounts of the development of empirical testing in the medical sciences, the thesis agues for the recovery of a romantic account of human physiology, in which the

imagination and meaning are active and embodied. It therefore offers to link the bodily and the instrumental through an extended-materialist account in which the physiological, rather than the psychological, is central. Developing a response to constructionist models of the body and instrumentation, the thesis concludes that a model of the poetic may be adopted as a method for understanding the opportunities and imperatives inherent in the avoidance of deterministic approaches to biosignalling technologies.

In doing this, the thesis contributes particularly to the creative arts and technology research practices concerned with the use of body sensor technologies in humanistic applications. It complements the existing works by artists in this area that make use of instruments by assembling a number of theoretical readings and interpretations of how instruments work – among them the thermometer, lie detector, and automatograph – which illustrate the argument that that is possible to operate from a theoretical position within which instruments are both material, performative and symbolic.

Contents

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There was a particular phase of writing block I suffered last summer, where every time I opened this document, I would be faced with an empty version of this page, and imagine the wonderful things that I would write on it. I made myself wait until this penultimate moment so that it might serve as my reward; to put down on paper a few of the many 'thank yous' that I have been carrying around for years.

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Author's declaration and word count

At no time during 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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During the period of the research, work in progress that reflects and has aided the development of the ideas in the following thesis was presented at a number of relevant conferences and research seminars including;

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Hannah Drayson

February 2011

Preface

At the outset of the research that led to the writing of this thesis, I envisaged that its final product would be primarily technical. My research topic was biosignalling[1] technology and its use in producing human body visualisations.[2] My research question regarded an investigation of the possibility of generating visualisations that were non-reductive.[3]

I embarked upon the project from my existing knowledge base, in the visual arts and computing, and began practice-based research. My early work explored the use of biosignal visualisation and sonification[4] in visual arts and performance.[5] Immediately, certain questions began to arise, most particularly

[1] Biosignalling refers to a range of usually electrical devices that are used to measure human body states. Most familiar are the electrophysiological sensors used to measure bioelectrical phenomena such as the signals from the heart, brain and muscular tissue. Typical body states measured are muscle tension, heart rate and blood pressure. In addition to electrophysiological devices, there are other sensor types such as mechanical, chemical and electrical sensors. (Cacioppo et al. 2007). This range of sensor technologies, as well as having clinical uses for patient monitoring, are also used in disciplines such as psychophysiology and biofeedback therapy.

[2] Visualisation is the practice of designing new ways in which to visually represent abstract data, usually using computer based graphic synthesis and interaction. (Ware, 2004: Chen, 2006).

[3] Biosignal measurement as a practice identifies a number of distinct functions of the body, which are measured using electrical, mechanical and sometimes chemical sensors. Prior to computerisation, signals would have been recorded as graphic traces on smoked glass or paper rolls. Contemporary sensor systems often incorporate digital sampling at varying degrees of resolution.

[4] Sonification is the auditory equivalent of visualisation, representing data as sound in order to aids its interpretation.

[5] This research led to workshop and conference presentations of biosignal based visual and sound based collaborative artworks at ICMC 2008, eNTERFACE'07 and NIME 2008 reported in collaborative papers *An Interactive Bio-Music Improvisation System* (Tahiroğlu, K., et al. 2007) and *Audiovisual content generation controlled by physiological signals for clinical and artistic applications* (Benovoy et al. 2007). However, this work is not commented on in any detail in the following because the methodologies used to create these works do not illustrate in any useful fashion the theoretical approach proposed

regarding the nature of instrumentation itself, and what it meant for me, as an arts practitioner, to be using it. Was it necessary for my use of instruments to be rationalised by technical methods borrowed from scientifically established protocols? In what sense could my work approach the relationship between psychological states that could be measured by observing the state of the body and the realm of the experiential? Can a relationship between the bodily and the psychological be articulated, without being reduced or mechanised? Was the relationship between instrumentation and scientific reality fundamental; could there be an instrumentation of arts? Many of these questions can be seen to remain linked to the following thesis, but have evolved with it. In particular the context for this project being an original preoccupation with the use of sensing technology in the arts may be seen as having had an influence on the research process. I note this here in the preface because this particular problem is not one that is central to the thesis' discussion, but can, in retrospect, be seen to have had a stake in what has emerged from it.

The exploration of body sensing in the arts, whilst, by some, still currently perceived as 'high tech' is by no means novel. Artists have explored electrophysiological sensing, particularly brainwaves, and signal analysis in musical performance and art since the 1960's. Alvin Lucier's *Music for Solo Performer* (1965) used percussion instruments that were resonated in response

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by the thesis. Only one early performance, *(un)controlled experiment* (2007) (described in *Audiovisual content generation controlled by physiological signals for clinical and artistic applications*) explored, to some extent, my preoccupation with instrumental reduction and the limits of representation.

to the performer's brainwaves. Richard Teitelbaum's *Spacecraft* (1967) featured EEG (electroencephalogram – brain) and EKG (electrocardiogram – heart) control of synthesizers (Miranda and Brouse, 1995).

More complex models of feedback response, where performers became part of a feedback loop, as emerging from early biofeedback[6] methodology, were used in performances. David Rosenboom's *On being invisible* and *On Being Invisible II* (1994-95) described in his Monograph *Extended Musical Interface with the Human Nervous System* (1997) employed neurofeedback[7] using a system designed to recognise and respond to measurable neural aspects of music perception.[8]

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6 Biofeedback, or 'applied psychophysiology' (Schwartz et al. 1995, p.xix) is the practice of using biosignalling technologies to train human subjects to exert voluntary control over physiological functions. Subjects are asked to observe graphic or auditory representations of those functions that are measured in real-time using biosignal sensing devices. Clinical biofeedback is the application of this method in a medical setting to help train patients to self regulate a range of dysfunctions of the body. Amongst these are the use of biofeedback to treat Reynaud's syndrome, hypotension, ADHD, urinary and fecal incontinence, muscular disorders, bruxism and on (Schwartz et al. 1995).

7 Neurofeedback is a form of biofeedback specifically concerned with the measurement of electrical signals from the human brain, known as electroencephalography. This measurement is achieved using electrodes (sometimes large arrays) attached to the scalp. The electrical activity of the brain in different regions can be inferred by comparing the electrical differentials of electrodes in different positions. Changes in voltages can be interpreted as certain frequencies referred to as 'brainwaves'.

8 At different times, Rosenboom has created performances using systems designed to respond to changes in brainwave frequencies associated with different conscious states. This area of research into the use of electroencephalography (EEG) for musical control continues to the present in the work of researchers such as Eduardo Miranda (Miranda, 2010) at ICCMR at Plymouth University. Other researchers are also involved with the use of EEG alongside other forms of biosignal, using physiological measures of heart (electrocardiogram), eye (electroculogram) and muscle (electromyogram) for example. This 'multimodal' approach has been pioneered by Biocontrol System's 'Biomuse' system originally developed at Stanford University

Currently there are numerous artists working with a variety of sensor types. George Phookin Khut's interactive artworks, *Cardiomorphologies v.1* and *v.2,* and *res'onance-body [-box]* incorporating electrocardiography (heart) and respiration sensing (Khut, 2006) exploit the biofeedback model of the way that conscious awareness of physiological state can aid its voluntary alteration. Khut describes his artworks using body-sensing as encouraging "audiences to observe and reflect on aspects of their own psychophysiology, using the technologies of biofeedback interaction as a way of situating the participant's subjectivity and bodily experiences within each other as reciprocal phenomena" (Khut, 2006, front matter).

In the majority of artworks that use biosignalling, data is analysed and used to generate visual or sonic representations in real-time.[9] This is quite different to how the majority of scientists or physicians use measured physiological data, which is recorded and analysed for the traces of known diseases or changes responding to particular stimuli, as will be discussed in the following chapters. There are of course exceptions to this, in a number of medical and clinical practices where real-time representation of signals are used; for example biofeedback therapy, a clinical application of real-time biosignalling, treats patients by making them aware of physiological changes of

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(Lusted and Knapp, 1988; Knapp and Lusted, 1990) used by Atau Tanaka for interactive music performances.

[9] In a sense, real-time signals experienced by an audience might be better considered as physiological *media*, rather than scientific *data*.

which they would not usually be conscious and medical monitoring for surgery or nursing.

Developing robust systems which can collect, analyse and display data in real-time is a technical challenge that has meant that this area of artistic research has been somewhat under the influence of the development of cheap computing power and the development of robust and easy to deploy sensors, and data transfer methods. This means that there is still work going on which uses similar methodologies to those pioneered by artists like Rosenboom decades ago (Brouse, undated). The hardware and software now allows real-time performance of complex forms of data analysis, researchers have been able to use analysis techniques to identify emotional states in theatrical performers, for example by collecting and analysing multiple sensor types simultaneously (Benovoy et al., 2007). Many artists, including myself, have used biofeedback instrumentation to explore the use of physiological signals in artistic or performance contexts, because of its cheapness and multimodality.[10] Because it is intended for a clinical market, biofeedback equipment is also sold

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[10] Example units of these type are those from the Thought Technology 'Infiniti' product line (http://www.thoughttechnology.com/) and Mind Media's 'Nexus' units (http://www.mindmedia.nl/) both of which can be used with a flexible range of sensors. Hardware systems developed for use in the arts include ICubeX and Biocontrol sensors have also been used by artists and musicians. Many biofeedback units have a range of sensors, making them suitable for some forms of electroencephalography, as well as electrocardiography, electromyography, skin resistance, respiration and temperature measures. This range of sensors, and their cross-reference is referred to as 'multimodal analysis'.

as a convenient 'black-boxed' product[11] and therefore suitable for users who are not biomedical engineers.

There are certain reasons that the biofeedback paradigm lends itself to repurposing as a structure for interactive artworks and performances. It demands the real-time presence of the subject, attached to the machinery of sensors. This confirms the relationship of their person to the output of the system and also imparts meaning to the visualisation. The logic of biofeedback is that through their presence, attention to, and experience of the visualisation, the audience of a biofeedback artwork is cognitively influenced by their own bodily phenomena, which are manipulated by the technological and aesthetic decisions taken by the artist over how to represent these phenomena. This complex interaction between spectator, artist and technology, is explored by Brigitta Zics' doctoral thesis Transparency, Cognition and Interactivity: Toward a New Aesthetic for Media Art (2008) and work on her project *Mind Cupola* (2008). Zics' work is concerned with generating an aesthetic paradigm for understanding artworks that use technologies such as eye-tracking and thermal imaging to measure audience-participants. In these kinds of artworks the subject is kept whole by default, even when the signals being collected by the systems and represented might refer to a reductive set of phenomena of the body.

[11] 'Black box' is a term with roots in electrical engineering where it was used to refer to a part of an electrical system that has a known input and output, but could be deployed in the design of a system without knowledge being needed of the workings of the component or how it functioned. Bruno Latour and Steve Woolgar (1979, p.150) and Vilém Flusser (2000, p.16) both use this term to refer more generally to technologies which are used without knowledge of their workings.

The knowledge and methodologies of scientific and medical disciplines, such as clinical biofeedback and psychophysiology[12] allow artists to create interactive artworks and performances that, using sensor instrumentation, respond to, and interact with, the psychophysiology of the human body. Using a combination of somatic bodywork theory, phenomenology and biofeedback methodology informed by cybernetic principles, artists like Khut and Rosenboom have developed arts practices which offer technologically mediated experiences of physical subjectivity, both amplifying and influencing audience/performer's physiologies and rendering the physical subjectivity of the body palpable. Khut's work builds upon an understanding of 'the body as a subjectivity' (Khut, 2006, p.6) a position shared by my own work and that of the philosophers I draw on in my first chapter.

Real-time display is a compelling way in which to experience the body as mediated by technology. In addition to this, adoption of the biofeedback paradigm by artists also has certain philosophical advantages. In particular problems relating to how the 'subject', whose body is being measured is understood to relate to the data collected. This relationship, using the biofeedback paradigm, is cybernetic. It explains the interrelation of subject (audience or performer), instrument and visualisation, as inherently and naturally linked. However, this paradigm appears to preclude an articulation of the meaning of bodies and their relationships with instruments as part of a

[12] Psychophysiology is the "scientific study of social, psychological, and behavioural phenomena as related to and revealed through physiological principles and events in functional organisms" (Cacioppo et al 2007, p.4).

discursive or symbolic realm of meaning. Using the biofeedback paradigm (judiciously) avoids raising questions regarding the relationship between meaning and embodiment, perception and symbol that the thesis (imprudently) instead attempts to unearth. It is for this reason that the thesis is concerned with a discussion of the placebo effect, an effect that is complicated when knowledge, meaning and symbol are incorporated into a model of biologically active forces that are instrumentally accessible.

The biofeedback paradigm has become associated with a number of tropes regarding instrumentation and technologised bodies. The role of technology as mediator between the body and the subject varies, and is at times a force disconnecting from the body/world, and, at others, reconnecting (in particular in the use of clinical biofeedback). This idea will be discussed in more detail in the first chapter of this thesis, the notion that biofeedback (particularly electrophysiological) technologies offer an objective measurement of the body, and can make apparent to users aspects of physiology that they may otherwise neglect. It is the aim of biofeedback training to train humans to have access to voluntary bodily control that they always lacked, or have lost. When artists make use of the biofeedback paradigm in their work, they often explain the rationale of the practice as one that reconnects the bodily and the subjective, as Khut (2006) puts it, making visible the 'reciprocal' nature of psychophysiological phenomena.

Where my project diverges from, and hopefully contributes to, this approach is that it critically engages with how sensor technology itself is understood, particularly in scientific epistemology. As a methodology it offers the potential for a particular type of aesthetic experience to be produced. However, the danger of accepting biosignalling instruments without examination of their accompanying explanatory frameworks is that doing so may encourage a determinist view of these technologies. It passively accepts the convenient positivist tropes often attached to them, such as the popular biofeedback concept of linking to an authentic bodily experience, which may have been forgotten, or 'disemburdened'[13], or providing a cyborgian enhancement of body perception.

My project can therefore be seen to run alongside the investigations made by artists of the way in which technologies can be used to mediate and enhance bodily experience. The aim is to create a discussion of instrumentation that complements these works by interrogating the notion of instrumental technologies as representations. Instead it offers them as embedded within, co-extensive and co-defining of bodily ontology representing, knowing, describing, and creating are all collapsed.[14]

Those artists currently working with biofeedback technologies, biosignalling and brainwaves to create music, performance or interactive

[13] Peter-Paul Veerbeek (2002) discusses this idea in Borgmann's philosophy on human experience and the negative effects of technology upon it. See also Drayson (2009) (included in the appendix) for a brief discussion of this idea in reference to physiological instrumentation.
[14] Ontology is the philosophical study of 'being' – or 'what is', the philosophical exploration of aspects of the world, rather than the philosophical investigation of how that world is known – epistemology. Karen Barad (2007) has offered the term *onto-epistemology* to describe the relationship of what is known and how it is known to what is.

artworks are not themselves committed to the natural dualisms that have historically accompanied discussions of sensor technologies. This thesis is concerned with extending an alternate philosophical framework within which these practices might be understood, particularly the way in which instrumental practices interact with the human body, in as Khut puts it a 'reciprocal' fashion, but further to this, a formative fashion. This thesis will show the occasions where taking a closer look at instruments could provide important insights into the use of instruments which does not take them as tools, but offers a framework in which to understand their relationship with the symbolic.

For this reason this thesis includes an examination of how instrumental technologies have been traditionally conceptualised in the philosophy of science. Most particularly with how aspects of creativity might be wound into an account of its use that would serve those concerned not just with the surface of the technology, and its existing use, but the interrogation of what degrees of freedom and flexibility might be open to exploitation by creative practices. The thesis attempts to show how an account of instruments that are material, performative and symbolic might inform a use of them in creative practices.

It has been my aim to create an account of how the instrumental measurement of human bodies can be considered to be essentially creative, and to offer an augmentation of the biofeedback paradigm illustrated partly by reflection on the discourses surrounding the 'placebo effect'. By denying any ontological difference between the realms of the instrumental, material, biological and objective, and the phenomenal, meaningful, and subjective, the thesis sheds light on how physical devices enter into the interplay of making, mattering, and objectifying the immaterial, a realm that it might be considered the role of artists to render manifest.

This thesis presents one of many paths that can be taken through this philosophical territory. It can only offer a partial account of the breadth of what exists, because of the diverse literatures that it draws on. However, while they might forgive the brevity with so much ground is covered, readers should benefit from its small addition to a discourse that maps wider, transdisciplinary concerns with technology, ontology and the body. I would like also to hope it might offer the reader an indication of some of the stranger possibilities that lurk in the spaces between the philosophies of the human body, and practices using measurement instrumentation.

Introduction. Gestalt Biometrics and their Applications

One way to explain this thesis relatively simply is to refer to one way of understanding the difference between the arts and the sciences. The ideas that began this investigation related to how we might understand the use of technologies developed for scientific use in medicine as tools for artists. The apparent difference between these realms can be seen in the idea that the sciences measure and explain, and the arts create. However, this thesis is based upon a well-developed scholarship that argues that there are other ways of understanding scientific practices and technologies.

Rather than conceptualising scientific practices using measuring instrumentation as essentially revealing, their role being the rendering visible of an authentic reality, the process of measurement one developed to make use of certain technologies for the measurement and recording of this reality, this thesis draws in a conceptual framework that considers scientific practices as constructive. The literatures of the philosophy of science, history of science, philosophy of technology and the sociology of science and medicine, in different places, offer an increasing range of insights into the ways that we might think about this constructive nature of scientific practices with reference to instrumentation and instrumental measurement.

The thesis aims to develop our understanding of these ideas with reference to a particular use of instrumentation, to measure the human body. To do this it contributes a transdisciplinary synthesis of the history and philosophy of science and technology relevant to a particular subject area, human body instrumentation, taking into account a number of contemporary scholars and disciplines, as well as a range of examples of different types of technology, to explain and explore these ideas.

The thesis deals with the quite familiar territory of scientific objectivity, and the importance of mechanical registration using instruments to the idea of objective measurement. A reassessment of the role of instruments in the context of their interaction with the human body is a discussion that might at first appear rife with dualisms. The themes that emerge from these dualisms are dealt with in the early chapters of the thesis. The notion of instruments as essentially objective, operating in contrast to, or on a different level to the quotidian world of bodily experience, led me to examine the philosophy and history of science through the work of scholars like Lorraine Daston and Ian Hacking. The work of these scholars is important because it clarifies the relationship between objectivity and instrumentation, where it can be retained, and where it is misleading.

Central to this discussion is the thesis' account of the placebo effect, an instrumental artefact manifested by controlled testing, which is both held as one example of the way in which instrumentation is used to structure the world in order clarify the effects of certain variables on certain physical outcomes, and at the same time, the effect demonstrates the way in which the meaning of measurements and structuring activities carried out on the body essentially modify it, and finally, as the discussion moves to the lie detector, a devices that uses the placebo effect this clarifies the way in which instruments may even be understood to make use of meaning and symbol to evoke and structure aspects of the body.

These observations may seem trite when examined, in fact it makes sense to understand physiological instruments in this way, for instance, the manner in which the blood pressure cuff tightens around the arm is one example of the obvious way in which instruments are not passive observers, measurers, but that they actively create certain 'laboratory conditions'. This knowledge has been part of the philosophy of science for centuries, as articulated by thinkers such as Francis Bacon, as we will see in Chapter 2. The philosophy and social sciences have made much ground, following in the footsteps of thinkers like Michel Foucault, in uncovering the ways in which scientific structures, such as forms of medical diagnosis, give human individuals particular theories and understandings of their own embodiment and subjectivity, so scientific meaning and structures shape human lives.

Instrumental measures, be they made using devices, or structures of measurement, such as questionnaires, therefore modify their objects. It is in this observation that the thesis proposes its contribution, and articulation of the impact of the role of meaning within instrumental practices which is highly useful if artists are to use scientific devices of measurement in their work – particularly interactive artworks. Finally, it is important to deal with devices and physiology because this area seems less contested, also the way in which artists innovate using computer technologies often impacts upon the way in which those technologies are innovated upon and appear in consumer devices, therefore the structuring effects of these instruments, and the fact that they do not offer an authentic body, one that is unfettered even by conscious thought or knowledge is an oversight. It invites a particular way of considering the body, as an object that can be acted upon, managed and modified. While there may be benefits to this approach, if this way of thinking about the body is normalised, becoming part of day-to-day life, it closes other possibilities. When making a measurement, decisions are made about what is relevant, and what it is below the instrument, those decisions shape what is. This is both a creative invitation and a caution.

Biometrics as a research topic

The goal of the research project that gave shape to this thesis was to propose a 'gestalt' human measurement technology, a project that demands a response to the question of how those aspects of human beings that have traditionally been excluded from bodily materiality by classical philosophy can be understood as technologically accessible. The focus of this thesis is upon a particular type of instrumental technology – 'biometrics' – devices used for measuring human bodies. However, it is not concerned with the application of biometrics for the identification of individual human beings. Instead the thesis is an exploration of the general understanding of what 'measuring biology', '*biometrics*' might refer to in how the human body is made sense of within the practices that use these types of devices.

To this end, the thesis mobilises a broad definition of *biometrics* – as technologies used for the monitoring and representation of changes in human bodies over time. Evidence of this broad focus is the variety of different devices that appear within the text. The discussion will include, if only in short; methods for human pulse measurement, stethoscopes, thermometers, polygraphs, randomised controlled trials, the sphygmograph, x-ray, ultrasound machines and a finally, a somewhat obscure turn-of-the-last-century psychological measuring apparatus named an 'automatograph'. While it contains some lengthy discussions of instruments as things and as theories, the thesis does not provide a taxonomy of biometric instrumentation or a history of it, aside from those histories it provides in order to illustrate its argument.

For all the apparent variety in this list, what brings these instruments together in the thesis is their relationship with scientific objectivity, the way in which they are used in scientific methodology and offered as an answer to particular epistemological challenges. The thesis will discuss some of the ideas that shape how we understand mechanical data registering devices, and their use, as practices of the rationalised and automatic, having a special relationship with physical matter a relationship also renders instruments problematic when we consider instruments in contact with the human body.

Physicalism and psychophysiology

Part of what concerns this thesis is the changing notion of what aspects of human beings might be considered 'instrumentally accessible' within research practices such as psychophysiology. As the thesis will show, the idea of what constitutes a measurable aspect of a human body or human experience is one that has, and will continue, to fluctuate. The thesis proposes that instruments have a role in changing notions of what constitutes human experience, human existence, and concurrent understandings of the materiality of that experience.

The practice of using instrumentation to measure psychological states emerged as a science in the mid-to-late 19th century[15], and was accompanied by considerable debate regarding the efficacy and the moral significance of identifying human conscious experiences as observable, causal and possibly mechanical bodily processes. As Daston (1978) identifies, in Britain, an emerging 'scientific psychology' found itself in a difficult position between the 'reductionist', 'mechanistic' tendencies of Victorian science and the imperatives of moral philosophy (p.192). Reductionist models and laboratory experiments threatened to reduce human volition to reflexes and destroy both the capacity for ethical conduct and the moral necessity of free will (p.194).

While the thesis is not intended to offer a history of instrumentation associated with any particular historical period, it draws on a number of histories to illustrate its discussion of the use and understanding of instrumentation in different contexts. The scientific discipline of psychophysiology, which arose in the 19th century, took as its project the quantification of phenomenal experience.[16] To track the relationships between the psychological with the physiological, by positing (as Wilhelm Wundt did) that the mental was simply the obverse of the physical, rather than as it was previously considered, following René Descartes, an ontologically separate realm altogether (and therefore accessible only to philosophical introspection and not quantification) (Daston, pp.196-197).

[15] The first psychological laboratory was opened between 1976 and 1929 by Wilhelm Wundt in Leipzig, Germany (Cattell, 1928).
[16] In Wundt's laboratory in Leipzig the psychology of vision as well as the sense of movement and time perception were studied (Cattell, 1928).

Proponents of the new psychophysiology found themselves having to deal both with philosophical and methodological problems regarding how the relationship between mind and body might be formulated and quantified. But at the same time their project was beleaguered by the moral philosophical fears raised by claims that 'mental contents' might be accessible to physical instrumentation.[17]

Within the prevailing physicalist ontology that informs the majority of scientific disciplines in the 21st century, there are no longer aspects of human beings that are not 'instrumentally accessible'. The popularity of scientific trials which use MRI scanning to map the relationship of different parts of the brain to certain types of psychological tendencies or events might appear to render further discussion moot. The doctrine of physicalism appears to mean that instrumentation can be understood to have access to the 'inner', the phenomenological landscape of the human mind, and that a dispute between mind-body philosophies is resolved.

To consider examples of those things that in a traditional philosophical account might be described as mental, but in the sciences are the focus of instrumental measures, we could refer a number of key concepts that can be found in literature of psychophysiology; for example, the concept of stress, as a

[17] Daston's (1978) paper on this subject tells us that one response to the ferocity of these debates was the development of the concept of 'will' within psychology. This enabled this aspect of human beings to be dealt with and maintained as a part of the scientific discourse. However, the concept gradually faded through the 1930s and following decades as religious imperatives became less influential and scientific trends led scientists to compartmentalise their understandings of the relationships between day-to-day life and the objects of their study (p.207).

biological response by individuals to their environments and experience. An understanding of the notion of stress caused by what might be considered as 'non-physical factors' on human health; have existed in Western medicine since the 17th century (Cooper and Dewe, 2004, p.2). Since then it has served as an adjunct to the understanding of the role of physical and biological factors that cause disease and led to the development of detailed physiological accounts of stress associated with mental states and perception of different situations (Kaltsas and Chrousos, 1992).

Emotion research is another related area of contemporary psychophysiology. Researchers in fields such as Human Computer Interface (HCI) design have for some time been working towards robust algorithms that can be used identify differing emotional states in human subjects from electrophysiological sensors measuring a variety of physiological signals (Levenson, 1992; Picard, et al., 2001; Lisetti and Nasoz, 2004. pp.1-16; Benovoy et al, 2008).

It is important to explain here that this thesis does not claim that activities that use body measurement always take a reductive approach to the body, or that mental categories are always excluded from the categories of accessible bodily phenomena. In fact the early pioneers of psychophysiology – figures like Ernst Weber (1795-1878)[18], Gustav Fechner (1801-1899)[19] and

[18] Weber discovered a lawful relationship between the incremental change in weight held in a subjects left and right hand, and their perceptual awareness of this change, allowing him to formulate *Weber's Law*, which reflected the sensitivity of the perceptual system to change (Benjamin, 2007, pp.31-3).

Wilhelm Wundt (1832-1920), – were concerned particularly with the measurement of perception, through introspective self report of subjects, an idea that went out of fashion in favor of more objective and behaviourist tendencies of their students. James Cattell (1928) who studied under Wundt is a good example of this. Noting that whist a student he failed to make a successful study of his assigned topic – reaction to changes in coloured light – because of his professor's requirement for students to make use of introspective measurements. Cattel notes that he grew frustrated with the 'limitations of introspection' (1928, no page number), a frustration that eventually led him to carry out a number of his own experimental investigations in his boarding rooms. While introspection as a scientific method went out of fashion, it remains clear that the philosophical categories which might have once been correlated with mental and physical are not adhered to by contemporary scientific disciplines of psychophysiology. However, as will be discussed in the following, these ideas have maintained a presence through a scientific epistemology connected with these distinctions, which has influenced the way in which scientific instrumentation has been thought about since the mid-eighteenth century.

[19] Heidelberger's (2004) work on Fechner's philosophy of science shows that Fechner was pursuing a science that incorporated conscious experience as entirely measurable and accessible through instrumental measurement.

Subjects and Objects

The thesis is based upon an underlying philosophical premise regarding the nature of human beings as embodied subjects. It takes physical bodies as having a fundamental and embedded subjectivity that inhabits the same ontological stratum as the instruments that measure them. This understanding of subjectivity, as an essential part of the flesh that walks and speaks and sees, is one which has been explored in philosophy at length and argued for convincingly. A number of scholars, such as Richard Rorty (1980) and Elizabeth Grosz (1994) have surveyed, supported and developed this position are introduced in the first chapter of the thesis. The discussion of their work provides an underlying rationale and confirmation of the thesis' approach to understanding the body. It is one aim of the thesis to attempt to understand how this subjectivity, immanent to human beings, and human bodies, can be articulated as an attribute open to measurement by physiological instrumentation.

In addition to philosophies of the body, the thesis also responds to literature that has emerged from the philosophy of technology and sociology of science, which critiques how the 'sight' afforded by instrumentation, is understood to relate to reality. Much of this discourse also revisits other problems raised by subject/object distinctions and understanding the ontology within which instrumental science operates. Therefore, in untangling this relationship, it references various problems regarding how human experience, phenomenology and meaning may be understood in reference to instruments intended for the measurement and representation of human physiological function.

Many scholars in the philosophy of technology and science studies have proposed a different set of conditions than those that gave rise to philosophical questions like those that surround the mind-body problem. The distinction between mind and physical matter that is the result of a discussion of instrumental measurement of the body. Alternatively, a different set of problems comes from the question of how instruments bring certain aspects of the bodily into being, rather than an illuminating practice, bringing to light what is already there, it proposes that instruments are a materialising force. What the thesis is concerned with drawing out of this literature is that these sciences are creative themselves and that the devices that they use might be considered as such also, in particular ways that afford particular interventions by artists. It is not the case that the possibilities for these interventions – as will be discussed in the case of the lie detector - are not already being explored and exploited by users of instrumental devices, however, what the thesis aims to make clear is the implications of these uses to the way in which instruments are conceptualised by their users.

Contribution of the thesis

The major part of the thesis' contribution is the exploration of a particular approach to understanding scientific measurement in the specific case of human body instrumentation. This approach was developed in the philosophy of science by thinkers like Gaston Bachelard and Neils Bohr.[20] As Bachelard and Bohr (and many who have followed them) have held, the practice of measurement should not be understood as one that simply makes available accurate data about the state of the world. This realist understanding of the role of instruments can be rejected. In its place can be developed an understanding of instrumentation as one of many methods by which human beings make sense of reality, by developing structures, and physical systems that interact with matter in certain ways. However, there is a further, and fundamental, coda to this idea; that by making forms for understanding, the objects of study themselves are modified, influenced, materialised.

In the case of human body instrumentation this idea is one that appears to be particularly important, not least because of the authoritative role that diagnostic technology currently holds in medical practice. The thesis marshals responses to the problem of understanding human measurement from many disciplines, maintaining that they all have a converging awareness of particular problems regarding how human beings are understood as

[20] I will engage with the work of Bohr in the thesis through Karen Barad's (2007) development of his ideas regarding measurement in the sciences and her linking of this to the sociological literature that explores medical imaging practices such as fetal ultrasound.

products of instrumental practices. For example, drawing on medical anthropology offers the thesis access to existing (and long running) discussions of problems in the application of scientific ideas such as those that rationalise the use of instrumental technologies in a humanistic domain, medicine.

Some of scholars drawn upon in the following have started to offer work that explores this territory. For instance, Karen Barad (2007) has drawn on sociological studies of ultrasound scanning to explore the implications of her position regarding measurement as a materialising practice in the context of the human body. As Barad points out, there is an existing scholarly history of technologies of bodily management, which builds on the work of Michel Foucault, and on some thinkers from feminist scholarship, such as Judith Butler. The thesis can be seen to link to a lineage of scholarship that seeks to understand the role of technologies, as structures for describing human existence, and therefore shaping human life and experience.

One might argue that this research is necessary because we live in an increasingly technologised context. In many societies, human beings are subject to an increasing number of technologies for automatic surveillance, measurement and categorisation. As Irma van der Ploeg (2003) notes in her essay on biometric identification technologies; '[...] in various domains of society and spheres of activity, ranging from work, health care, and law enforcement, to consumption, travel and leisure, [...] the generation, collection, and processing of body data is increasing' (p.58).

Electrophysiological and other biosignal sensing is one area influenced the effect of the increasing ubiquity of computerised media. Innovation in biosignalling research and the dissemination of consumer technologies which incorporate these technologies is driven by a number of range of applications for novel forms of computer hardware inputs; use in relaxation, rehabilitation, or other biofeedback therapies, as peripherals for home computing, games and creative applications, as computer interfaces for those with a variety of physical disabilities, such as paralysis and in health and fitness monitoring. The present popularity of concepts like mobile and ubiquitous computing are opening up an increasing availability and diffusion of computing resources (necessary for auto-recognition of body states, data storage etc.) which can be put towards the use of body sensor enabled devices in day to day contexts, and also offer applications for further research in affective (emotion aware) computing.

For all this apparently novel development, it is also the case that understanding how instrumental technologies shape human bodies and experience is an ongoing problem that has a long lineage. As will be discussed in chapter 5, the adoption of metaphors of medical and instrumental concepts of the body into everyday life, and the influence of these types of description on lived experience are not novel. For example nosological (disease) categories have often been associated with instruments of measurement, such as the thermometer. The application of medical types of body sensing have long been envisaged as an outcome for diffusion and remain the goal of current research in fields such as ambulatory and telemedicine. At least since the Enlightenment there has been a tendency for thinkers and physicians to apply technological metaphor to understanding human bodies and psychological mechanisms (my use of the term 'mechanism' in this context is an apt example).[21]

The idea that technological progress and novelty should motivate research in body sensors is however not really central to the thesis' motivation. Approaching these technologies as essentially novel as a standpoint from which to think about their adoption in the arts and can too easily accept the form that they take, leading to attempts to find uses for them as they are offered. Instead the thesis attempts to assemble the ground, much of which is already in place (or nascent in other disciplines and discourses), for understanding the way in which the use of sensor technologies can be understood as a creative activity. The thesis aims to respond to the issues that have been identified in other fields in response to measurement and instrumentation, such as anthropology and philosophy of science, in order to demonstrate that accepting these devices as having a straightforward, realist relationship to the body neglects a form of creative practice that might otherwise emerge. For this reason the thesis aims to develop an account that looks at instrumental measurement as creative and productive of human bodies.

[21] Julien Offray de la Mettrie's *L'homme Machine* (1748) famously conceived of man as a machine, building on (and critiquing) Descartes' use of this metaphor.

The use of examples in the thesis

The thesis discusses a number of examples that are considered as contentious: the placebo effect, the lie detector test, and the automatograph. One reason for these choices is that these contentious examples are situated in the discourse where most free-play is available. As Bruno Latour (1987) maintains of his own methods in the analysis of technologies, it is where alliances and theories have not been reified, where there is still controversy, that there is still space to question what they have or could become, and the assumptions about the world that they incorporate, that interventions and reassessment of technological systems may be made.

The examples discussed are not intended to clarify a particular technical aspect of biometric practice, but instead to reveal how instrumental measurement systems are sometimes used to detach and reattach human bodies from human subjectivities. It does this in order to offer a way of understanding the application of a "gestalt biometrics" in the arts, an understanding of instrumentation that includes its symbolic and meaningful functions. The example of the placebo effect makes it clear that the biologically active properties of symbol and meaning are a problem in some practices, such as medical testing. However, these same problems may be useful if reincorporated into other practices.

The thesis articulates a modified relationship between instruments and bodies. It suggests that an account of human bodies and their relations with instruments which does not neglect to consider the way in which knowledge is constructed, and how bodies respond to meaning might result in a different understanding of instruments and their use. Instead of the orthodox conception of instrumentation as offering objective representations of reality through a particular and privileged material relationship with the world, instrumentation may be better considered as a collaborator, and an active and creative tool.

Overview of the structure of the thesis

In **chapter 1,** the thesis begins by offering an account of the body which is, as Wittgenstein described it in his later works, something through which the interior is expressed, a thing which *is* behaves as and is experienced as 'suffused with meaning, thought, passion and will' (Hacker, 2007, p.5). This body as 'suffused with meaning' is the 'gestalt' body of the thesis' title. In order to clarify this concept of the body, chapter 1 introduces the notion of 'extended materialism' recognisable in a number of philosophical accounts of the human body as well as the concept of a 'flat ontology'.

When applied to a concept of the body, extended materialism recognizes the inherent nature of the physiological and symbolic as manifested by the body (as well as technology, language, culture, and environment). By understanding the body in this way, the thesis intends to suggest that in fields where reductive forms of measurement are not so crucial, such as the arts, a range of subjective and internal states could be, and are, produced by biometric technologies.

Drawing on explanations of extended materialism devised by a number of scholars, the chapter makes clear how this form of philosophical materialism differs from the position usually associated with the term. By maintaining an understanding of the physical world that it is non-reductive, and an awareness of the changing nature of scientific definitions of how material reality may be constituted, is developed.

The following chapter, **Chapter 2,** examines the orthodox relationship of instrumentation to scientific epistemology and the concept of scientific objectivity. It shows that there are certain aspects of the way in which instrumentation can be used that are considered 'objective' which are useful, but that a number of other concepts of objectivity should be discarded. This is because they confuse an understanding the relationship of instruments to material reality as well as the human body by conflating mechanical registration of data with access to a pre-existing and objective physical reality, and the ability to represent that reality in a straightforward and unreconstructed way.

Chapter 3 extends this analysis of objective measurement using instrumentation to a discussion of medical technologies. It shows how human body measurement technologies tend to be associated with discourses of objectivity and a simultaneous denial of subjectivity by historians of medicine. From this starting point the chapter sets out to provide an adequate account of the more general effects of a move away from dualist epistemologies in the understanding of scientific instrumentation. Informed by the contemporary literature, it gives an account of how instruments are understood to be a integral part of the production of phenomena, and analyses the medical humanities literature which describes current theory on the way in which medical activities and instrumentation in particular shape the body through the process of representation.

In **chapter 4**, the thesis draws upon the philosophical literature that concerns itself with an exposition of instrumentation, mainly in the sciences.

This allows the thesis to show how it is possible to set aside the traditional epistemological project of knowing the world 'as it is' or the 'things themselves'. Instead the practice of using instruments is re-modelled, as the practice of verifiably setting up a relation of effects and causes, creating 'instrumental' relations that describe entities; the use of an instrument is to isolate one form of thing from all others and to link it to a trace. What this description of instruments also establishes is that it is not linked to materiality or any particular kind of physical composition in the classical sense. To provide this account of instrumentation the thesis follows the arguments of Gaston Bachelard (1984) and Karen Barad (2007) that instruments are more usefully described as ways in which the world is produced from within, rather than devices that give an authentic access to or illuminate an existing, but inaccessible, reality. In this revised view, instruments do not represent a pre-existing world (and neither do scientific illustrations and data, theories or models) but are a form of intervention upon that world. The multitude of different instrumental interactions that can be made on the world represent the many ways of assigning and measuring different attributes of that world, many forms of description/interaction.

The discussion in **chapter 5** of the production of disease categories through a range of medical practices is intended to show that in practice, bodily phenomena are untidy and pragmatic, they are produced for different purposes and often cross boundaries. This discussion demonstrates that bodily phenomena such as different types of disease can be understood as historically, culturally and instrumentally contingent. The chapter discusses examples of disease categories which have been shown to be historically and culturally contingent and in some cases, contingent upon the invention of particular measuring technologies. The chapter discusses the way in which certain apparatuses have given rise to the possibility of diagnosis of certain pathologies, and introduces a the concept of an 'expectant clinic' from Michel Foucault's *The Birth of the Clinic* (2003).

Chapter 6 discusses the 'placebo effect, and 'meaning response' as products of the invention of the controlled trial, an instrumental structure used for testing the efficacy of medical treatments. Dealing with the historical conditions and concerns of the pioneers of this controlled testing in early-nineteenth century medicine, the chapter examines the way in which a concept of the imagination was produced and dealt with by two different trials carried out to test the medical claims of mesmerism. These concepts of the imagination are not held to be consistent, but are held demonstrate an important aspect of instrumental set-ups; the way in which they can be used as arguments that establish certain aspects of human life or meaning to be important or unimportant within the wider context of medical scientific practices.

Chapter 7's discussion of the 'lie detector test' and its final reflection on the 'automatograph' applies the account of instrumentation produced by the thesis. It also extends the previous chapter's development of instrumental accounts of apparatus that produce meaningful phenomena. It introduces and extends Geoffrey Bunn's argument that lie detector testing is a form of performance; and further, argues that this performative dimension might be validly considered an active part of instrumental practices, not one that should be subtracted from our overall understanding of what instruments are, or how they operate on a symbolic dimension.

Chapter 8 turns toward a speculative discussion based on the writings of Richard Rorty. Based on Rorty's development of the concept of the poetic as a pragmatic response to the creative construction of meaning, it suggests that there may be an alternative, poetic strategy, for thinking about instrumental practices outside of the sciences, particularly in the arts and creative practices. By reminding human users of the technology of language that they are engaged in a practice of 'world-making', the constructive aspects of language, as an expression of the bodily and subjective are explored in a discussion of the doctrine of poetics. This finally delivers a method, already central to artistic practices, for reconceptualising the possible roles that instruments might play in creative practices.

Terminology used in the thesis

This section defines a range of terms that appear throughout the text. For some it provides only a starting point for ideas that are progressively modified through the argument of the thesis. Foremost amongst these are **instrument, instrumentation** and **instrumental**. The thesis is primarily concerned with instruments as *tools that measure.*[22] It is not concerned with instruments used as tools for manipulating bodies, such as scalpels, or musical instruments used for making sounds. The thesis embarks from a similar notion of instruments to that used by Latour and Woolgar in *Laboratory Life* (1979, p.51-2). Here they describe instruments as *inscription devices*, which produce scientific inscriptions by interacting with matter and therefore produce correspondences between particular phenomena and marks. Chapter 4 explores and extends this idea.

Within the thesis, the term **apparatus** is used to refer to assemblies of instruments. The two terms, instrument and apparatus are to an extent interchangeable. As defined by Latour and Woolgar, both words are concerned with the production of an inscription and an **instrumental** connection, between phenomena and mark; they "transform pieces of matter into written documents" (1986, p.51). An apparatus might have a longer number of actions, stages or devices, between its object and final inscribed outcome, but is still intended to maintain the same claim as simpler instruments. Both instrument and apparatus operate to link the material world with a representation or recording of it.

It is worth commenting on the relationship of the category of devices that we refer to as instruments with a notion of the **instrumental.** Within the thesis, this term does *not* refer to Dewyan *instrumentalism* in the philosophy of

[22] Oxford Advanced Learners Dictionary (1995, p.619) describes an instrument as 'a device that measures speed, distance, etc or records information about the operation of sth, e.g. an engine'.

science. Instead it refers to a notion of **instrumental rationality,** as it is understood as a method of enquiry in the physical sciences. This rational enquiry links logical and mathematical reason with physical instrumentation (in philosophy this term can also refer to the ethical rationale that is used to justify action). As measuring instruments are generally understood to be structures that allow the measurement of an aspect of the physical world. They are understood to do this by producing logical and rational relations between physical phenomena and information about those phenomena.[23] When something is said to be *instrumental* it is understood to have a causal and possibly mechanical relationship with an effect.

Some measuring instruments are used to make automatic recordings and graphs, digital numerical logs, or photographs, such as the electrocardiogram. Some instruments, such as the microscope, are used to aid observations made by human observers. Chapter 2 will discuss the apparent differences between these types of instrument, and the concept of **mechanical**

[23] Ian Hacking, (1983, p.187-208) argues that the relations between phenomena and scientific observation are more often than not established via through observation and use, rather than logical, theoretical descriptions of instrumental devices. He uses the example of the microscope to show that while our theoretical descriptions of the instrument are highly inaccurate, it is still understood to work because it enables a verifiable interaction with matter that can be confirmed at the level or normal human vision. Hacking, like Kuhn (1961, p.162-7) suggests that there is a 'text book' view of instrumental measurement which is informed by the way science is taught which encourages a particular reading of instruments and their relations to and descriptions through scientific theory.

objectivity[24], which informed mid-nineteenth century scientific 'best practice' as modelled on machines used for automatic data registration.

Objectivity itself is a recurring theme and dealt with in depth in chapter 2. The term refers to a mixture of philosophical ideas (Daston and Galison, 2007) that require clarification and dissection. One of these, is that it is possible to provide an account of physical reality on its own terms, which in turn informs the idea that there are distinct **'objective'** and **'subjective'** positions from which to know the world and forms of knowledge about human bodies.

The thesis attempts to avoid providing anything more than a loose and provisional description of **subjectivity**, and this is dealt with in chapter 1. This is because, as will be shown, the notion of the subjective as an antonym of the objective produces it as an interior essentially separate from the rest of the world. The effect of this is a philosophical position where the interior of the subject becomes inaccessible to the material; the material (and real) becomes unknowable to the individual. Chapters 2 and 3 aim to explore the complexity of this dialectic; the discussion relates both to early scientific empiricism and the adoption of scientific methodology in medicine as well as its relationship to philosophical understandings of human knowledge and the **human body** and subjectivity and meaning as integral to the body.

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[24] The term 'mechanical objectivity' is adopted from Daston and Galison's *Objectivity* (2009), where they also discuss other epistemological principles manifest in the history of scientific atlases, 'truth to nature' and 'trained judgement'. Porter (1996, p.3-4) also identifies 'mechanical objectivity' similarly, as machine-like, rigorous and restrained, alongside other forms of objectivity, 'absolute' and 'disciplinary' objectivity.

The primary concern of the thesis is with a discussion of instruments that are used to measure **the human body**. Chapter 1 goes into some detail regarding the exact ontological properties of the body that the thesis is concerned with. This clarification of the body as an **'extended material'** entity which combines mental and physical within a non-dualistic framework, a 'gestalt' body, is central to the thesis argument regarding the way in which instruments can depict, interact, shape and **materialise** the human body.

The term **materialism** in its philosophical context can be understood as referring to the notion that that the physical sciences can account for the totality of what exists. However, an awareness of historical changes in scientific knowledge will alert us to the fact that the context in which 'material' is defined is constantly shifting. As the Oxford Companion to the Mind (1987) notes: 'The word 'materialism' sometimes misleads. The materialist is not committed to a Newtonian 'billiard-ball' account of matter' (p.490). Materialism instead is linked to the physical theories of its day.[25] Because of this 'relativity' to physics, philosophical materialism is also sometimes referred to as **'physicalism'**.[26] This serves to distance the position from its entanglement with now dated science and historical contexts, such as the move

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[25] In the 18th century for example, being a materialist would meant a commitment a definition of *matter* as "an inert, senseless substance, in which extension, figure, and motion do actually subsist" (Berkeley, Principles of Human Knowledge, par. 9).
[26] As the Stanford Encyclopedia of Philosophy explains; "...while physicalism is certainly unusual among metaphysical doctrines in being associated with a commitment both to the sciences and to a particular branch of science, namely physics, it is not clear that this is a good reason for calling it 'physicalism' rather than 'materialism.' For one thing, many contemporary physicalists do in fact use the word 'materialism' to describe their doctrine[...]"

away from vitalist theories.[27] Within the thesis, physicalism and materialism may be considered as broadly interchangeable terms. However, it should be understood that the materialist position that the thesis takes is a particular one, of **extended materialism.** The thesis adopts this from Ronald Schleifer (2009) and Elizabeth Grosz (1994) and its particular implications will be explored in chapter 1.

The theme of **materialisation** is also important. This term refers to the appearance of something, becoming material, and therefore perceptible. Karen Barad's (2007) work, discussed in chapter's 4 and 5, develops a notion of **'mattering'** (p.141) in terms of the production or **'materialisation'** of **phenomena** by instrumentation. The thermometer, for example, makes the phenomena of temperature materialise in a particular way. The use of the thermometer in particular circumstances leads to the temperature **'mattering'**. Temperature becomes palpable, comparable, measurable, and also important (as noted in the short history of the thermometer in chapter 3, the ability to measure temperature led to a modification of, and increased importance for, the diagnostic category of fever). Barad's play on words reminds us that drawing human attention to something, making it detectable and perceptible through measurement makes it 'matter' in both senses of the term, raising its importance, and its material and objective qualities.

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[27] Taking the view that human and animal life did not require anything 'more' than the same components and structures of organisations that are present in inorganic matter in order to be living, hence Rene Descartes' likening of human and animal bodies to machines. (p.491).

Meaning, and the **symbolic** are both terms that I have adopted from Daniel Moerman's discussion of the 'meaning response'. Moerman's work responds to a paradigmatic lack of recognition regarding the role of "experiencing knowledge, symbol and meaning" (2002, p.4) as factors influencing human biology in the field of medical science, and in the scientific testing of medicine.[28] Like the 'subjective', these terms remain somewhat in flux throughout the thesis, as they refer to a broad collection of phenomena that vary from one context to another, and are often contingently identified. My concern is not particularly with providing an account of what might be called **consciousness, phenomenal experience, imagination, qualia,** or **subjective experience.** This is because all of these are aspects of the human gestalt that is central to the thesis' understanding of what human beings are, and therefore fit into the account of an extended materialist body. Past the early discussions of this gestalt, the thesis gains little from further defining them when they appear as an embedded and assumed part of the human body. The time when this is not the case is when these terms are used to refer to something that is manifested – or denied – by instrumental apparatus, such as the role of meaning and subjective experience in lie detection, or the construction of the imagination as either crucial or dismissible in the discussion of the placebo effect.

[28] Latour (1993b, 2005) critiques the 'symbolic and subjective' as worthwhile concepts for discussion, defence, and reintroduction into sociology, maintaining that by referring to these concepts, a false dichotomy is maintained.

The term **'gestalt'**, from the German for 'form' or 'shape', is used in English to denote 'wholeness' or 'holism'. In the context of the thesis this term is used to refer to the totality of human bodies and minds that the extended materialist account of human bodies describes in chapter 1. As a term it creates a tension with the concept of instrumentation, the role of which is to divide and to define, and therefore to describe.

An analogy I have often returned to which helps to think about gestalts, language, reality and instruments is that of **cutting a cake**. The cake, as a whole, is our gestalt, there are endless different planes and forms into which it can be sliced, (the pragmatic, and in English culture normal, way to do this is to cut what is known in mathematics as a 'circular sector', a slice). However we decide to cut the cake renders different parts of the cake distinct from one another, open to different discourses of contrast and distinction. The thesis proceeds from the understanding that reality is undefined until perceivers or instruments make a **'cut'**[29] and that any cut made is, rather than

[29] Barad (2007) has substantially developed a notion of cutting with reference to a posthuman concept of bodily reality prior to ontological boundary distinctions such as nature-culture (See Barad's discussion with reference to Pickering and Haraway on p.136). She uses the term 'cut' to refer to the way in which measuring instrumentation 'performs cuts', 'every measurement involves a particular choice of apparatus, providing the conditions necessary to give meaning to a particular set of variables, at the exclusion of other essential variables, thereby placing a particular embodied *cut* delineating the object from the agencies of observation' [my emphasis] (p.115). Her concept of 'agential cuts' focuses on the work of instrumentation as nonhuman actors that produce phenomena through these processes of inclusion and exclusion (p.172-175). Incorporating a concept of technological agency situates Barad's reading of Bohr in posthumanist scholarship (p.32). Barad's thesis might be extended to human beings in an instrumental analysis of the human perceptual apparatus, which responds for example, to certain frequencies of light and sound, but excludes others. Through

being arbitrary in a relativist sense, a process by which meaning is imposed upon the world.[30]

The term **biomedicine** is often used to denote the contemporary practices of 'western' medicine, which is considered to be, and presents itself as being, based on scientific principles of evidence, rationality and objectivity. However, to propose that within the Western medical system that there is a general concept of the body, or a way to rationalise various systems and medical specialisms that produce a variety of bodies in different settings would be to assume hegemony that does not exist. As Anne-Marie Mol (2002) notes in the introduction to her book *The Body Multiple*, the notion that **Western, Cosmopolitan, Modern or Allopathic medicine** has any unity is a trope which 1970's Sociology of Medicine might be accused of perpetrating, but even then only in the light of that scholarship's preoccupation being with establishing other claims against 'medicine' (Mol, 2002, p.3-4). Mol's anthropological work strongly suggests that biomedical bodies are more pragmatically divided into different areas of expertise, by hospital workers and

particular material configurations of the body, these frequencies take on difference resonances within the body.

[30] This formulation is clearly highly indebted to Barad's work, but earlier in the research process to Richard Rorty's work, which in its critical analysis of the philosophical notion of truth, makes comparable similar arguments about the relationship of language to reality. (Rorty and Engel, 2007; Rorty 2009) Both are committed to what has been observed to be a 'antirepresentationalist' position which rejects the idea that there is 'true' or optimal way to relate language to reality (Rorty, 2009, p.xv) and that there is a 'separation between words and things' that it is the role of epistemology to correctly configure (Barad, 2007, p.137). Finally, I set out on this trail after reading (and perhaps misinterpreting) the words of Gaston Bachelard (1984) on scientific instrumentation, that 'science projects' rather than makes the world visible.

communities, between different technologies used to measure or treat. The sociological critique of biomedicine's neglect of the subject can partly be attributed to the way in which the body is refracted and fragmented across multiple lines of distinction between needed and unneeded information (p.51).[31]

Despite its theoretical commitment to scientific values, the methodological complexity of biomedicine means that a holistic body concept that could be understood to guide medical interventions should be seen as an unlikely goal. The biomedical body appears to have clear boundaries in the way that it is taught, if not in the way that Mol and others have observed it to be practiced. Textbooks and anatomical atlases provide clear boundaries and maps of the territory of the body. This territory begins and ends with the skin. Bodies can appear, when depicted in this way, as clearly defined objects, but this reality is belied by the question of ownership of body parts removed during surgical procedure, cultured cells, the permeable membrane between

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[31] As is the case in the sciences, it makes more sense to consider the different institutions that do medical research and perform medical treatment, as delineated by numerous fields of expertise and interest. Each of these take widely different bodily systems and functions as their objects, often they are further differentiated by the technologies that they use. Take for instance the range of hospital departments, opthamology, pediatrics, midwifery, neurosurgery, chemotherapy, occupational health, maxillofacial, medical imaging, musculoskeletal, oncology, immunology, the range of departments are many, their connections and flows multiple. Specialisms may divide the body by organ system, other departments specialize in diseases that may not be fixed by bodily locality, in areas where diagnostic decisions need to be made, or surgery carried out, physicians and surgeons often need a high level of familiarity with the part of the body that is being treated. Mol's work (discussed further in Chapter 5) has made these multiplicities visible by following a particular disease through a hospital, where it could be observed transformed by numerous sites.

bodily part and waste matter, peeling skin, faeces, blood, all of which might flip-flop in and out of the context of comfortable inclusion and disgusting 'abject'.[32]

So while it is inaccurate to discuss 'biomedicine' as an entity or movement, there are certain philosophical tendencies within these allied practices that in a general sense can be set in distinction to the concept of the body that is used by this thesis. Daniel Moerman has observed that American medical education is 'rich in a particular kind of science'. He points out that the 'Medical College Admission Test' includes a section on 'physical sciences' including 'levers', 'inclined planes' and other 'simpler' science that is more typical of 'seventeenth century' physics than the complexities of medicine or even contemporary physics (Moerman, 2002, p.13). Moerman suggests that this emphasis on the simplistic and mechanical may have some part to play in the criticism that physicians have attracted for their 'attempt[s] to manage all diseases by means of engineering interventions' (Illich, 1975; p.53), and that 'it often seems to bother doctors enormously that the *fact* of receiving medical treatment (rather than the *content* of medical treatment) can initiate a healing process' (Moerman, 2002, p13). There is a tendency following this type of training to overly rationalise bodily processes and to discard information about the circumstances of patient's lives, narratives or subjective experiences as peripheral to the information gathering necessary to produce an effective

[32] The abject is a theoretical concept of the bodily other developed by Julia Kristeva (1982) drawing on Lacanian psychoanalysis.

diagnosis or treatment (Good, 1994). However, it could be argued that an underlying lack of appreciation for complexity and ambiguity, and an overly reductionist view of **phenomena** could be considered a beneficial approach to the performance of medicine when quick, pragmatic and confident decisions are necessary.

Finally, **phenomenon** is a term that has a variety of meanings and may be taken by some readers to refer its philosophical meaning as it relates to the phenomenological qualities of perception. As Ian Hacking (1984) reminds us, **phenomena** as defined by Kant are the way in which things appear to the perceiver, defined in distinction to noumena – 'things in themselves' of which an account cannot be made, for they cannot be known except through the phenomenal world (Hacking, 1983, p.98).

Hacking (1983) and Barad (2007) use the term as it is understood in the sciences, to refer to the observed objects of scientific study. Hacking (1983, p.220-232) points out that the term is a 'philosopher's minefield' coming as it does from the Greek for a 'thing, event or process that can be seen' (p.220) and therefore being immediately implicated in philosophical discussions regarding the relationship between 'appearance and reality' (ibid). He observes however that the word has:

> [...] a fairly definite sense in the common writings of scientists. A phenomenon is *noteworthy.* A phenomenon is *discernible.* A phenomenon is commonly an event or process of a certain type that occurs regularly under definite circumstances. The word can also denote a unique event that we single out as particularly important (p.221).

Similarly, in Barad's work, the concept of phenomena that she adopts from Neils Bohr's philosophy is based on its use common use in the sciences to refer to 'that which is observed, that which we take to be real' (Barad, 2007, p.412). Barad, Hacking, and this thesis, therefore begin by using the term as it is understood in a scientific context, as aspects of the world that are repeated, reliable, important. However, it then goes on, as does Barad's work, to develop a notion of phenomena as fundamentally presupposed by some form of perceptual act, be that of an instrument, or a human observer. We might take them to be real, but phenomena are 'observed entities'. The phenomenological philosophical tradition therefore is reconnected with the instrumental and scientific.

Many of these terms and concepts, such as **phenomena**, the variety of forms of **objectivity**, and **instrumentation,** which have been introduced above, will continue to be developed throughout the text as the thesis explores how they might be and have been re-described in order to make its argument. Finally, a few **other terminologies,** such as **poetics,** will be introduced in footnotes or described in the main body of the text at the first point that they are used in the thesis.

Chapter 1. The human body as the 'stuff of subjectivity'

> The body is a most peculiar 'thing,' for it is never quite reducible to being merely a thing; nor does it ever quite manage to rise above the status of a thing. Thus it is both a thing and a nonthing, an object, but an object which somehow contains and coexists with an interiority, an object able to take itself and others as subjects, a unique kind of object not reducible to other objects. Human bodies, indeed all animate bodies, stretch and extend the notion of physicality that dominates the physical sciences, for animate bodies are objects necessarily different from other objects; they are materialities that are uncontainable in physicalist terms alone. If bodies are objects and things, they are like no others, for they are the centers of perspective, insight, reflection, desire, agency. They require quite different intellectual models than those that have been used thus far to represent and understand them. I am not suggesting that medical, biological, even chemical analyses of bodies are 'wrong' or 'inappropriate'; my claim is the simpler one that the guiding assumptions and prevailing methods used by these disciplines (indeed, by any disciplines) have tangible effects on the bodies studied. Bodies are not inert; they function interactively and productively. They act and react. They generate what is new, surprising, unpredictable (Grosz, 1994, p.xi).

In this excerpt from *Volatile Bodies* (1994) Elizabeth Grosz draws our attention to what she sees as two aspects of the human body, both of which have an important role in the thesis. The first is that bodies are more than 'material' in a traditional sense; they are animate. Second, this animation is reflexive; human bodies are knowing and aware. Because of this, Grosz (drawing on a number of other scholars whose approaches she synthesises) argues that creating forms of representation of the body ('medical, biological and even chemical analyses') also operate to produce it.[33] As a consequence the way in which the body is understood affects and shapes its physical expression.

It is the aim of the thesis to understand these two observations with reference to biometric instrumentation (measuring devices that make particular observations of the body possible). The thesis is concerned with how devices of this kind can be understood as productive of bodies, and to extend this notion of production to ask in what sense practices using instrumentation might be considered creative. This chapter establishes a number of points and definitions to clarify how the body is understood to relate to subjectivity, meaning, and materiality.

One aim is to describe an underlying philosophical understanding of the material constitution of the body that supports the thesis' exploration of instruments as productive in this sense. To do this it will offer a clarification of Grosz's first observation, that classical explanations of the material are 'stretched' and 'extended' by human bodies. It will do this partly by showing how classical philosophical models of the material and its relation to mind as essentially separate or different have been rejected. This discussion will serve to clarify that the subjective or mental are neither ontologically, nor epistemologically separable from bodily materiality. By doing this, the first part

[33] This way of approaching the human body, as something produced, or at least radically transformed, by discourse extends across a number of disciplines, anthropology, medical history, psychoanalysis, philosophy and feminist theory. It can be seen more as a general approach to understanding human embodiment than as a specific episode or movement in the scholarship. It will be returned to in more detail in Chapter 5, but it is beyond the scope of this thesis to offer as complete an account as the one that Grosz's work synthesises.

of the chapter will justify the adoption of an alterative position to dualistic models of the body.

While they may tend to appear self explanatory, and perhaps fundamental, to a philosophical discussion of human bodies, the categories of mental and physical have been systematically analysed and rejected by some contemporary philosophers. In order to clarify what this means, and how it relates to scientific instrumentation, the following discussion will introduce Richard Rorty's (1980) work on the mind-body problem. Rorty's work responds to, and builds on, what he observes to be a turn in philosophy against particular and entrenched models of man's ability to perceive the world and arrive at true knowledge. In making this analysis, Rorty demonstrates that the mental-physical distinction, so familiar in Western Philosophy, is the product of a particular philosophical and historical context.

Mind-body might appear a traditional and natural distinction to draw between the various aspects of human beings that we might discuss philosophically, or study scientifically. Rorty's account provides an alternate reading. That the body-mind distinction may more accurately be understood as the product of the development (particularly in the work of Immanuel Kant and Renè Descartes) of a philosophical discipline that maintained a realm of enquiry separate from the emerging physical sciences (Rorty, 1980, p.165-8).

Building on an initial rejection of a mind-body distinction, the second part of the chapter discusses its alternatives – accounts of the material body that do not contain what philosophers might think of as 'private', and 'personal' 'sense-data'. There are a number of scholars who have made it their project to move beyond these categories and explore an 'extended materialism'[34] of the body. The chapter does this by drawing on some examples of philosophical investigations that have begun by positioning the materiality of the human body as, (as Grosz, [1994] puts it), a centre 'of perspective, insight, reflection, desire, agency' (p.xi). The later parts of the chapter draw on the work of a number of scholars. Grosz (mentioned above) and Ronald Schleifer (1999) both provide accounts of bodily materiality and manifestations of subjectivity that transcend the classical materialist account of the human body.

The understanding of the body developed by this chapter is not prescriptive or final, being in part characterised by its common rejection of differences between mental and physical. However, the ideas it surveys share a common project, to (i) explore notions of an expanded materialism or physicalism and (ii) show how a philosophical account of the body may incorporate an understanding of the material embodiment of subjectivity. A result of these accounts which resist classical philosophy's 'ontological divide' is to generate what we might call a 'flat ontology' (Delanda, 2005, p.58; also attributed to Bruno Latour, 1993, by Harman, 2008; and Harris, 2005) of the body, the effects and possible drawbacks of this approach will also be

[34] This is not the 'extended materialism' first proposed by John Smythies in 1956 and explained in his 2009 paper, *Brain and Consciousness: The Ghost in the Machines*. Here he proposes a 'new form of substance dualism' and suggests that our materialistic concept of mind is 'extended' by 'phenomenal space' as two 'planes' or 'branes' of 'higher dimensional space' (Smythies, 2009, p.37).

examined in more detail in the following discussion.[35]

Finally the chapter can also be seen to relate one part of a story that links the mind-body problem with the history of the philosophy of science. The historical developments in philosophical epistemology that produced mind-body oppositions in turn affected the way in which the sciences understood themselves. Scientific studies which neglected certain aspects of human beings as 'unknowable' responded to discussions of what was a legitimate concern for scientific study, leaving some attributes of human beings to philosophy, often forgotten (later denied even by some philosophers[36]) as epiphenomena. As Hacking observes;

> Hellenistic writers contrasted phenomena to noumena, the things as they are in themselves. Kant transferred this to modern philosophy, and made the noumena unknowable. All natural science became a science of phenomena. Then came the cockcrow of positivism. The unknowable may be discounted, as if it did not exist. 'Phenomena' came to denote, for some empiricist philosophers, sense-data – private, personal, sensations (Hacking, 1983, p.221).

The concept of an 'unknowable' aspect of human beings, estranged from the physical world, has come to inform the scientific epistemology that often

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35 The thesis will refer to Graham Harman's (2008) interpretation (and partial critique) of Delanda's term, particularly as it has been applied to Bruno Latour's philosophy in his work and others (Harris, 2005).

36 Both Daniel Dennet (2004) and Paul Churchland (1981) have at different times put forward the thesis that internal and subjective experiences are epiphenomena, and perhaps illusionary, and that, most importantly, the question of whether they should be included in a discussion of science is moot as they have no influence or impact on materiality, the basis of their philosophy. This is what Richard Rorty (1980, p.18) would describe as a 'neo-dualist' position, because while all that falls into the category of the mental is discarded, the category remains as an alternative to the material 'real'.

used to explain why instrumental sensors, with their attributes of objectivity, and physical, mechanical functions, are useful. These ideas will be further developed in chapter 2, where an exploration of the origins of the concept of scientific objectivity, and its influence on how scientific and medical practices of body measurement are understood will be described.

What this chapter does not do is identify a number of aspects of the mental world and make a claim that they are instrumentally accessible. Instead, it describes a materialist concept of the human body that can act as foundation to a philosophical account of the body's relationship with instrumentation which can account for aspects of human experience that are not usually considered to be materially, objectively or instrumentally accessible. Introducing a notion of an expanded materialism that acknowledges the subjective as an attribute of the physical body allows the thesis to explore the creative potential of biometric instrumentation as a form of representation and bodily co-construction.

The mind-body problem

As discussed above, the following section will look at Richard Rorty's (1980) work on the mind-body problem, its relation to scientific epistemology, and the notion of an 'ontological gap' between the mental and the physical (p.18). It does this partly to draw attention to circularity in the relationship between philosophy of the human body, scientific method, and the scientific epistemology that explains why instrumental sensing is useful. It also serves to clarify that the interaction between physiological instrumentation and human subjects (and subjectivity) cannot be seen as clearly delineated by mind-body distinctions.

The mind-body problem is philosophical problem regarding how the relationship between mental and physical aspects of human beings is understood. Many strands of the Western philosophical tradition are characterised by a dualistic approach to describing the mental and physical, usually linked back to Descartes' mind-body dualism (Blackburn, 1994, p.245). The idea that form and matter can be separated dates back to antiquity,[37] and is a dichotomy which recurs through history; to Christian tradition, the European enlightenment, and into 20th century philosophy, and which still influences present day epistemologies (Grosz, 1994, p.5). Questions about the ontological status of certain characteristics of human bodily phenomena, such as those things which we might describe as mental aspects are relevant to the thesis because of the way they might be thought to interface – or not – with instrumental measurement technologies.

There are a number of different philosophical positions that have been formulated in response to the mind-body problem, primarily: monism, dualism, idealism and materialism (Gregory, 1987, p.490). The following

[37] The concept of a body (*soma*) as the home or receptacle for a perfect mind, reason or soul can be traced then from Plato, to his adoption by Aristotle, who proposed the conception of a hylomorphic body; one in which the relations between form and matter are brought together (Grosz, 1994, p.5).

discussion is not concerned with an exploration of these different positions. The thesis offers as an alternative a discussion of the roots of the mind-body problem in the history of philosophy, and shows how an ontological distinction between mental and physical has been rejected *as well as* an epistemological distinction. To do this, this chapter discusses in detail the argument regarding the historical contingency of the mind-body problem made by Richard Rorty in his *Philosophy and the Mirror of Nature* [*PMN*] (1980). PMN is a broad critique of a model that informs the western philosophical tradition, a model of philosophy as a practice concerned with the judgment of the accuracy of representations of other disciplines, and the veracity of their claims to knowledge (p.163-4).

As part of his attack on the problems generated by Descartes and Kant's[38] work to reform philosophy, Rorty uses his training as an analytical philosopher to synthesise a critique and rejection of the mind-body problem. He shows how the problem is generated by a wider discourse in philosophy, the idea of philosophy as a form of 'metacriticism of the special disciplines' (p.166) related to scepticism about scientific and philosophical knowledge.

He draws on a number of continental and pragmatic philosophers who have, instead of trying to solve 'perennial problems' (p.3) of Western Philosophy, reject them, and the terminology (and therefore premises) on

[38] As he describes it, "Ever since Descartes's attempt to make the world safe for clear and distinct ideas and Kant's to make it safe for synthetic a priori truths, ontology had been dominated by epistemology. So the 'naturalization' of epistemology by psychology [at the end of the the 19th century] suggested that a simple and relaxed physicalism might be the only sort of ontological view needed" (Rorty, 1980, p.165). This was clearly a problem as it apparently made philosophy redundant.

which they are based.[39] Rorty's work dismisses the existing approaches that attempt to resolve the relationship between physical and mental. These include proposing that one aspect is primary to the other, (as in classical materialism or idealism), theorising the mental and physical as two essentially different substances (this thesis is known as 'substance' or 'mind-body dualism')(Gregory, 1987, p.110) or discussing the relationship between these two aspects as being related to different epistemological positions (as in identity theory). Rorty's approach instead takes the categories of physical and mental as constructions that may be refused as unproductive.

Of particular importance is the way that Rorty tracks the history of the mind-body problem as presented in the Western Philosophical tradition[40], and the way it is dismissed by a number of philosophers, Nietzsche and Wittgenstein among them. He argues that the idea that there is a mind-body problem in contemporary philosophy is only attributable to a 'common-sensical and intuitive' (p.17) notion that pervades philosophical debates. This notion is that it is possible to make a division between the physical and the mental:

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[39] Particular amongst these is Ludwig Wittgenstein, whose alternative approach to understanding human beings will be returned to later in this chapter. Alongside him, Rorty names, and refers to Dewey, Quine, Sellars and Bergson amongst others, who undermined various aspects of Kant's notion of 'knowledge as accuracy of representations' and 'truth as correspondences' (Rorty, 1980, p.166).

[40] Throughout all of his work, Rorty historicises the philosophical problems that he therefore recognizing and charting the historical contingency of his subject, in contrast to the Cartesian-Kantian philosophy he critiques, describing it as; 'an attempt to escape from history–an attempt to find non-historical conditions of any possible historical development' (Rorty, 1980, p.9).

> We seem to have no doubt that pains, moods, images, and sentences which 'flash before the mind,' dreams, hallucinations, beliefs, attitudes, desires and intentions all count as 'mental' whereas the contractions of the stomach which cause the pain, the neural processes which accompany it, and everything else which can be given a firm location within the body count as nonmental. Our unhesitating classification suggests that not only have we a clear intuition of what 'mentality' is, but that it is has something to do with non-spatiality… Even if we discard the notion of 'mind-stuff,' even if we drop the notion of *res cogitans* as a subject of predication, we seem able to distinguish mind from body nonetheless, and to do so in a more or less Cartesian way (Rorty, 1980, p.17).

Rorty therefore suggests that it is the influence of a persistent account, and a related set of 'intuitions' regarding human beings, that separates the mental from the physical, and leads to the making of Cartesian 'mental-physical' distinctions, rather than technical or scientific evidence. He suggests instead that the mind-body problem can be better understood in Ludwig Wittgenstein's terms, as a form of 'language game', a 'pattern of activities and practices associated with some particular family of linguistic expressions' (Gregory, 1987, p.211). The mind-body problem is a discourse that generates the meaning of the terms that are used within it, terms which might not have any priority or usefulness in other contexts to describe their referent. Even now, when contemporary philosophical and scientific culture has rejected the notion of 'mind-stuff' or 'mental substance' that was incorporated in traditional substance dualism, Rorty argues that this language game causes a persistent tendency to think of the mental and physical as separable in a straightforward fashion (p.17).[41]

Responses to the problem

Rorty surveys a number of philosophical responses to the mind-body problem. These tend to take what he argues is an untenable 'neo-dualist' (1980, p.18) position. In this the categories of mental and physical remain unquestioned and what results is a collection of unaccounted for 'mental phenomena' which must be placed on one side or another of an 'ontological gap' (p.19). Some phenomena can be incorporated into accounts of the attributes of material organisms. As an example he refers to Gilbert Ryle's philosophy, in which 'beliefs, desires, attitudes and intentions' all become 'ways of talking about organisms' (p.18). However, other aspects of the mental, such as 'experiences, pains and thoughts' (ibid) because of the their phenomenal

[41] Stoljar's (2009) introduction to *Ignorance and Imagination* points out that, unlike the problem of consciousness (his own target) the mind-body problem is no longer an issue for the majority of disciplines, even contemporary analytic philosophy, which now follows the 'post-positivistic stance' (Rorty, 1980, p,12) of Wittgenstein. However, Rorty's thesis, like my own, is concerned with providing an historical context for understanding the historical effects of a philosophical tradition concerned with accurate representation of the world as it influences both discourses in medicine, through a persistent legacy of mind-body dualism and also in scientific instrumentation, in its influence on the understanding of the epistemological role and ontological status of instruments (particularly when applied medically). The combination of these two aspects of the thesis' interest make it necessary to include a discussion of the territory, even while contemporary philosophers may now consider it a closed debate. This aside, Rorty's observation that the language of the mind-body problem persists in discourse still stands (ibid).

character, seem to remain resistant to a material account, incommensurable with the physical aspects of the organism.

In some contemporary philosophical thought and in sciences like neuroscience and psychophysiology, a common response to the mind-body problem is identity theory, which is sometimes considered to be the same as physicalism (Blackburn, 1987, p.185). Identity theory posits that mental and physical aspects of humans can be thought of as two aspects of the same phenomena, the same thing observed from different perspectives.[42] This can be thought of as a contrast between subjective and objective viewpoints, to describe it, analogies such as the two sides of a coin are often used, one side mental, the other physical, but both essentially one thing.

There is a long history of philosophical objections and problems with the way in which identity theory is used (such as how different phenomena might be divided up from one another). However, Rorty rejects this solution primarily because it maintains a definition of the two categories of mental and physical (Rorty, 1980, p.19). These two aspects remain locked away from one another, their difference being that of alternate perspectives. The 'mental' is still inaccessible to the material world, even while it accompanies it as a

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[42] There are a number of technical variations on how this relation is figured, type-type identity theory claims that mental states can be reduced to particular physical states, type-token that they correspond to certain types of states, but cannot be mapped onto the same neural material with each iteration. McCauley and Bechtel (2001) propose a 'heuristic identity theory' which holds that the proposition of identities between psychological and neuroscientific states is ultimately useful to scientific practices – both in psychology and neurosciences, and that as a heuristic which accepts pluralism the construction of these notions allows the development of correspondence between different states.

mirrored counterpart. In this formulation, inaccessibility is no longer ontological, but is a matter of epistemology; the mental is objectively unknowable.

Identity theory solves the highly problematic ontological questions raised by traditional substance dualism, such as how body-mind interaction is possible. However one of the main problems produced by Descartes' formulation of material and mental as differing substance remains unsolved, the 'problem of other minds', that it is not possible to know or verify the content of another mind (Blackburn, 1987, p.100), even to verify that other minds exist. Mental contents remain scientifically inscrutable except through their problematic correlation with bodily phenomena, unless they are substantially reformulated.

Further to this, McCauley and Bechtel (2001) observe that identity theory leads to a dispute over the reduction of aspects of psychological phenomena to neurological, observed phenomena. If these two aspects are at basis identical, then in disputes where reductionist and anti-reductionist philosophers oppose one another, the question is whether or not it is meaningful to discard the psychological realm as a source of information. Anti-reductionists argue that the psychological realm's 'complexity' 'uniqueness' and 'irreductable' nature (p.739) prevent an 'intertheoretic' mapping. While holistic in spirit, this approach preserves an essentially dualistic model of the human subject.

The mind-body problem and the 'epistemological turn'

As discussed at the start of this chapter, the mind-body problem does not only impact on the thesis because of its influence on how we think about the human body and how it is conceptualised by practices using instrumental measurement. As will be explored in Chapter 2, the mind-body problem is a symptom of a philosophical heritage that impacts equally as strongly on the way in which the philosophy of science conceptualises and validates the use of instrumentation. By creating a distinction between human experience and the material world, a distinction reinforced by epistemological scepticism, philosophy, as described by Rorty (1980) and Hacking (1983) created a realm of mental 'phenomena' that is off limits to the physical sciences. This physical world is the one that is understood to relate to a notion of objectivity, separate from the mental sphere.

Reflecting this, Rorty's interest in the mind-body problem is only one part of a wider project to question the 'perennial' concerns of western philosophy since Kant. It is his argument that in the philosophy of this historical period, an over-riding concern with epistemology has generated a number of 'pseudo problems'. The apparent problem of understanding the relations between mind and body as they are understood in classical philosophy is one of these pseudo problems.

Rorty maintains that the 'epistemological turn' responsible for generating issues like the mind-body problem in philosophy was motivated by a need to preserve philosophy as a discipline from its continuing erosion by the success of the natural sciences. He traces the development of mind-body problem in philosophy to Descartes, Kant and Locke's attempts to establish philosophy as an investigation of the seat of knowledge from *a priori* principles. In Rorty's account, the need to establish claims to knowledge in the face of a highly sceptical philosophical position led to the emergence of a number of philosophy's traditional, apparently eternal, problems; the distinction between the mental and physical, the essential distance between mind and world, and finally, the establishment of a philosophy primarily concerned with epistemological questions related to knowledge, truth and representation.

Rorty traces a sequence of evolutions of the notion of mind[43] that reflect philosopher's concerns with giving an account of how clear knowledge might be arrived at. The starting point for this history is Descartes' 'cogito' (pp.17-69). Descartes' [44] philosophy employed a highly reductive form of scepticism, his arguments in his *Meditations on First Philosophy* question all aspects of his perception in the most stringent fashion. His commitment to this sceptical

[43] Similar to those charted by Daston and Galison (2007) in their study of 'objectivity' and its antonym 'subjectivity' which will be discussed further in chapter 2.

[44] Descartes' highly influential thought is often mentioned by writers on alternative medicine (Goldberg and Anderson, 2002, p.334) a practice where holistic views of the body are valued. He is considered generally to be the philosopher who 'divided mind from body'. This is a very limited view of Descartes' thought and, like this thesis, neglects much of the subtlety and interesting debate regarding *why* Descartes devised the philosophical system that he did. The idea that Descartes was a 'substance dualist' – in that he denied a possible causality between the physical and the mental – has been questioned in historical scholarship. A more nuanced view of Descartes' approach to the body and medicine can is highly recommended in Shapin (2000); on emotion and embodiment James (1999); and, for a discussion of some of the political and religious pressures on his work and an excellent biography, Grayling (2005).

approach is such that he suggests that his (and the reader's) experiences might be the work of an 'evil genius' (Descartes, 1929, p.16).

In the same volume, Descartes' performs an analysis of matter. He uses the example of a piece of wax, 'recently taken from a beehive' and 'placed near the fire' where it melts, loosing its smell, taste, sound when struck, and shape etc. (p.91). Descartes concludes that the only aspect of the wax that is constant is its material 'extension'. The wax, like the body, contains many attributes, but the only reliable one, the one that does not change over time and is therefore eternal, for Descartes, is the fact of its physical extension. The only aspect of the world that can be reliably considered to be material and knowable, the only thing that remains is its physical extension – its 'body'; all other attributes are mutable.

> What, then, was it I knew with so much distinctness in the piece of wax? Assuredly, it could be nothing of all that I observed by means of the senses, since all the things that fell under taste, smell, sight, touch, and hearing are changed, and yet the same wax remains. It was perhaps what I now think viz., that this was neither the sweetness of honey, the pleasant odour of flowers, the whiteness, the figure, nor the sound, but only a body what a little before appeared to me conspicuous under those forms, and which is now perceived under others (Descartes, 1929, p.90-3).

Descartes' example of the wax allows him to propose a highly reductive approach to the possibility of knowledge about the external world. He comments that 'I feel greatly astonished when I observe [the weakness of my mind, and] its proneness to error' (authors inclusion) (p.92). His, and by extension, all, human perception is thus rendered questionable by this 'error' of the senses, and also of the language with which he describes his observations (p.92). However, he proposes a manner in which his philosophical observation might continue, by observing what is left of the wax after the 'common sense' has been discarded.

> [...] what did I observe which any animal might not have perceived? But when I distinguish the wax from its exterior forms, and when, as if I had stripped it of its vestments, I consider it quite naked, its is certain, although some error may still be found in my judgement, that I cannot, nevertheless, thus apprehend it without possessing a human mind (p.93).

It is this 'human mind' that Descartes then sets out to establish as a viable realm for the perception of the 'intellect' (p.94), this is the realm by which that highly reduced and 'distinct' aspects of the world's extension might be observed. Above this however, he argues that it is the nature of the mind itself that is the most likely to be rightly apprehended, and provide distinct knowledge.

Descartes therefore questions the role of human perception and its value in knowing the world, essentially shutting off the mind from physical reality. In Descartes' philosophy, the cogito provides a realm in which 'clear and distinct' contents of thought might be formed and manipulated, and into which only very carefully observed aspects of the material world might be recorded. The cogito, in its immateriality, clarity and rationality, becomes the foundation for philosophical knowledge. A foundation, that because of Descartes' sceptical analysis of perception, the material world only offers in a limited fashion.

The development of the cogito is only the first part[45] of the development of the concept of mind that we would recognize in contemporary philosophy. The cogito was later adopted and developed by other philosophers, Emmanuel Kant and John Locke. Kant and Locke further modified the concept to include a range of attributes of what are now considered to be mental, that previously were not combined, bringing them together under the general definition of 'mental processes' (Rorty, 1980, p.4).

As Daston and Galison (2008) observe, Kant's philosophy was concerned with providing a rational underpinning to knowledge, what he introduced was a brand of thought which called into question empirical knowledge. He revisited the terms subjective and objective in order to bring them into line with his own thought – radically changing their meaning from their original use in mid-seventeenth century Scholasticism (Daston and Galison, 2008, p.206). Following Kant, the term 'objective' came not to mean as it originally had – "a representation of the mind" (ibid), but the opposite, as referring to external, independent reality. However, these terms were subject to an amount of slippage, and;

[...] the boundaries between the objective and the subjective [were drawn] in starkly contrasting ways: between the mind and the world, the certain and the uncertain, the necessary and the contingent, the individual and the collective, the *a priori* and the *a posteriori*, the rational and the empirical (Daston and Galison, 2008, p.207).

[45] Shapin (2004) and James' (1999) work both clearly show that Descartes had not entirely generated the concept of mind that is familiar to us today, emotions, for example, what he called the *passions* were considered to be bodily.

Rorty's, and Daston, and Galison's philosophical histories show that philosophy, particularly under Kant, was recast as the custodian and arbiter of claims to knowledge – from any field – including science. This functioned not only to preserve the discipline of philosophy, but also to create an artificial hierarchy with philosophy at the top, sovereign over all others. Cartesian 'mental-physical' distinctions were invoked in order to solve the problem posed by scepticism that led to the concern that philosophy has with representations – especially those taking place in the mind. As Rorty (1980) summarises;

> The notion that there is a problem about mind and body originated in the seventeenth century's attempt to make 'the mind' a self-contained sphere of enquiry. The idea was to offer a para-mechanical account of mental processes which, somehow, would underwrite some claims to knowledge and disallow other claims. The paradigm of the 'epistemological turn' taken by philosophy in the seventeenth century was what Kant called 'the physiology of the human understanding of the celebrated Mr. Locke'– a causal account of mental processes which is supposed to criticize and justify knowledge claims (p.126).

'Mind' as a conglomerate of concepts

This discussion brings to light the relationship between ontological categories (created in order to explain the relationship of different things to one another) and epistemology. Understanding how the development of the concept of mind and the development of the notion of objectivity (as an antonym to subjectivity) relate is useful for the thesis, as it shows us the way in which these ideas about accessibility and materiality are combined. Rorty shows us that the relationship between the set of aspects that are gathered within the notion of the 'mental' have been brought together to achieve certain ends, and are a construction that might be rejected, or modified in favour of a more useful concept. Rorty's writing on the mind-body problem shows the importance of an awareness of the historical conditions of the production of ontological concepts, his deconstruction of the historical conditions that made 'the invention of the mind' possible further supports his claim that 'nothing whatever hangs on the distinction between mind and body' (p.68).

As well as allowing Rorty to argue that a certain need in philosophy led to the production of a concept of 'mind', the histories which chart the development of these concepts show how they can be better understood as a conglomerate of different, quite dissimilar aspects of human experience, behaviour and perception. In Philosophy and the Mirror of Nature (PMN) (1980) Rorty offers a further critique of the Cartesian 'intuition' that mind and body fall into distinct categories, by analysing what attributes, such as intentionality, or spatiality, cause aspects of body and mind to be considered distinct. His analysis shows that these divisions are inconsistent and tautological. His allegation is that the apparent problem with mental-physical distinctions is not the result of an ontological divide that is intuited by philosophers (and confirmed by instrumentation) but the effects of the historical establishments of a philosophical-technical jargon that persists to this day. This jargon leads us to make distinctions which are arbitrary, in that they are not supported by ontological differences, regarding their relationship to materiality – and are also only defined epistemologically if a certain form of scepticism is invoked.

Even with the success of materialist, physicalist and behaviourist accounts of human beings in twentieth century sciences, Rorty argues that the persistence of intuitions about the 'mental-physical' divide cause problems for philosophical accounts of human beings that wish to avoid either dualism or reductionism. He also rejects the various attempts that have been made in philosophy to resolve mind-body distinctions. Based on the historical contingency of the problem, and the inconsistency of the ideas that it invokes, his conclusion is that discarding the problem entirely is the only sufficient answer. He concludes his argument by observing that the apparent problem presented by the 'private', subjective, or conscious experience, as inaccessible to other minds, is not an ontological issue at all, merely a problem of what he refers to as 'privileged access' (Rorty 1980, p.35). In Rorty's view there is nothing special about the 'private' aspects of the mind at all.

While the mind-body problem is a philosophical problem – the discussions in chapters 1 and 2 show the way in which philosophy of mind and scientific epistemology are closely interrelated. The strategy of using instrumentation, and our understanding of how human beings know and exist in the world are both related to underlying ideas of what human beings are, how they relate to reality, in particular how reality can be known. One example of this is that the estrangement of the knowing human mind from physical reality and the concept of the fallibility of perception, resulting in a particular form of epistemological scepticism, which is often used as a philosophical argument for the viability of mechanised measurement apparatus. Thus instrumentation is not simply a pragmatic device, but can be unpacked more fully, to open up a creative space of ambiguity about its relations to humans and to the world.

Non-reductive materialism

Rorty's response to the mind-body problem of critiquing and finally discarding the premise on which it is based, is informed by a broad survey of previous philosophy (in particular pragmatist), and the continental tradition that has rejected the traditional concerns of Western Philosophy. In his discussion of the body, Rorty draws particularly upon Ludwig Wittgenstein's behaviourist analysis of the way in which different aspects of internal states may be observed and attributed to the human body. Wittgenstein brings our attention to, and challenges the idea that certain terms belong to a set of entities that belong in the 'unobservable' camp - the immaterial. It is because they appear unobservable, that they might not be considered as viable inclusions in the practice of instrumental sensing.

Wittgenstein, like Rorty, considered philosophical problems like the 'essence of the self, the nature of mind, the possibility of self-knowledge, the relation of mind and body, and the possibility of knowledge of other minds' (Hacker, 2007, p.5) as productions of the kinds of philosophical assumptions in mind-body philosophy discussed in earlier sections of this chapter. Wittgenstein's tactic, later applied by Rorty, was to refuse to attempt to answer these questions, but to instead *dissolve* them, and reject the terminology and premises upon which they were based.

Wittgenstein's work on the concept of a philosophical psychology and his later works about the manifestation of the interior in the human body have been highly influential. His *Philosophical Investigations* (1953) along with various notebooks that he used in his teaching were published posthumously.[46] The primary contribution of his later works was the notion of 'language games', in

[46] Tractatus-Logico-Philosophicus (1921) was the only book Wittgenstein published in his lifetime, (*Philosophical Investigations* was published 2 years after his death). The *Tractatus* was intended to end philosophy, and once it was finished Wittgenstein took up a career as a schoolteacher. Philosophy survived – or continued at least – and the Vienna Circle, which formed around the time of its publication, was greatly inspired by the *Tractatus.* The book itself is a series of numbered statements intended to investigate what can be said logically, and therefore lay out the limits of philosophy as set by language. It opens thus; "What we cannot speak about we must pass over in silence." His later work, published posthumously as the Philosophical Investigations, is a radical departure from the self-assured analysis of the Tractatus. Wittgenstein's later work is far less grandiose, more nuanced, and untidy. It was criticised by his tutor Russell as being not philosophy, only linguistic analysis.

this view of human communication and logic; he eschews the traditional role of the philosopher as epistemological gatekeeper, and instead claims that all of human discourse is self-generating, reflexive and evolving.

What the next part of this chapter discusses is Wittgenstein's concept of the human, one that is entirely at odds with the Cartesian, empiricist and behaviourist traditions that operate in reference to the dualist mind-body ontology critiqued above. Like Rorty, he denies that humans have some psychological properties in the form of spiritual substance or that the mental is an inner realm. What is useful to the thesis about Wittgenstein's way of thinking is that he described a way of understanding human beings that is an alternative to the Cartesian model, but is neither reductive (and rejects psychological reality as useful) or dualistic, in that it claims that the psychological realm is real, but incommensurable with the material body.

P.M.S Hacker (2007) explains his position thus; 'Wittgenstein conceived of the mental as essentially manifest in the forms of human behaviour which give expression to "the inner"' (p.4. Hacker). Not only did Wittgenstein's writing deny that this inner realm was private in some essential way and that behaviour is the only outwardly observable and knowable aspect of human inner life - he 'emphasised that human behaviour is, and is experienced as being, suffused with meaning, thought, passion and will' (p.5, Hacker, 2007).

Wittgenstein's view of the body was that it's very material being could be considered to be the expression of this 'inner'. This formulation of the body offers the thesis a model of the relationship between the subjective and the physical that is not only not divided along ontological lines, but that epistemologically speaking it is also not a problem. Making clear what this means to an understanding of the body in the context of the thesis is the function of the rest of this chapter. It will do this by discussing the work of two scholars who have worked along similar lines to Wittgenstein, and extended and situated a notion of extended materialism: Elizabeth Grosz, mentioned above, and Ronald Schleifer. Particular to the approach of these scholars is their use of a form of philosophical materialism as grounding for their approach; however, the kind of materialism that they are concerned with is very different to the traditional notions of materialism as discussed in the introduction.

Materialism as a philosophical position

The philosophical position known as materialism – as it is traditionally understood – has historically posed an epistemological problem for instrumental sciences that have taken an interest in the human mind, as is shown in the history of experimental psychology, a discipline that sought to measure subjective states (Daston, 1978). As it is usually understood, materialism is often associated with reductionism, and the tactic of its proponents is often to subsume categories like the subjective or the mental into an underlying and primary notion of the world as physical, treating them as epiphenomena[47] – and denying them as non-existent or unimportant.

What the materialist positions discussed below have in common is their rejection of this tactic; instead they hold that a reduced and simplified account of the way in which the physical world constitutes entities and interacts with meaning is insufficient. The form of materialism that will be discussed below is not one that makes any major commitment to scientific theory, even present day. However it is concerned with sustaining a historical awareness of the necessary and inevitable flux that accompanies scientific theory.

Non-reductive materialism is less concerned with defining the mental and physical, and instead rejects the incommensurability of these out of hand – instead, it is a philosophical project concerned with the innovation of strategies for understanding and describing the materiality of phenomena that would traditionally be associated with mental experience.[48] The goal is to move

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[47] An epiphenomenon is a secondary phenomenon that is caused by another, but cannot itself have causal effects. In the philosophy of mind 'epiphenomenalism' is the position that mental states are caused by physical phenomena but cannot have effects themselves (Gregory, 1987, p.298).

[48] Traditionally in reference to the body-mind problem, there is a broad division regarding how a commitment to materialism might be reconciled with a non-reductive concept of mind. The choice can be summarized as being between the 'peripheralist' and 'centralist' view of where 'mind' is situated. A peripheralist account is often referred to as behaviourist. In the philosophy of mind, behaviourism is the view that 'the possession of a mind is constituted by nothing more than the engaging in of especially sophisticated types of overt behaviour, or being disposed to engage in such behaviour in suitable circumstances.' (Gregory, 1987, p.491) This view is not the same as the psychological methodology that denies that observation of internal and subjective states can be considered as valid scientific evidence *(ibid)*. Wittgenstein's approach can be considered as behaviourist, however it is methodologically so, rather than ontologically. It does not deny the existence or relevance of the inner to scientific

towards an understanding of the body as a physical, material expression of the subjective. The concern of the thesis is with understanding and clarifying what such a move taken by this scholarship might signify for how the particular practices of instrumental body sensing are understood.

Traditions of the body in continental philosophy

Continental philosophy, when taken as a tradition can be seen to have a particular approach to the body which offers a useful alternative to the Cartesian condition that encourages an epistemological doubt regarding embodied knowledge and experience. Many contemporary continental philosophers have rejected the idea that there is an essential world that might be found to correspond more or less accurately to the inner representations of the perceiver, language, or scientific representations. The accuracy of human perception or other forms of representation can still be questioned, but the underlying assumption that there is an essential something to which these perceptions or representations should be accurate *too* is questioned. The problems posed by epistemology are therefore no longer an issue, and different models of human interactions with the physical world are posed. Key to these ideas for the thesis, is not only the notion that there is a reciprocity between representations and physical matter, but that the symbolic is itself part of the same ontology as physical matter.

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or philosophical study, and in fact argues that they are immanent to the physical nature of the body.

There are a number of 'key factors' that Schroeder (1998) identifies in the continental tradition's treatment of the body that will be visible in the discussions of the philosophers who feature in this chapter. Key to understanding the continental tradition's approach to the body is its analysis of the body as 'a system of habits, desires or volitions' (Schroeder, 1998, p.620). Scholars in the continental tradition have sought to generate an account of 'human existence generally, rather than just the mind or intellect'; where humans are situated in nature, comprised of 'systems', 'emotions', 'institutions', 'habits', 'the psyche', 'practical' and 'temporal' aspects, aspects which contribute to the complexity of this account of the body, the challenge of which is related to 'the interactions among these central factors' (p.619-620). The body does not exist prior to these different interactions, but is generated and modified by them.

These other aspects of the body that the continental philosophers refuse to let go are central to understanding what a 'gestalt' body might refer to in the context of the thesis. Rather than take the body as object, as a set of organ systems described in an anatomical atlas, or the fleshy extension of the human, or even something that might be understood both as object, and as person, as a thing with phenomenal experience and characteristics, the body within the thesis, is radically constituted by those aspects which might have once been separated out into the realm of the mind, emotion, or other states of being or experience which are interior rather than exterior.

This distinction is important, because of its relevance to how a 'gestalt biometrics' might be understood. A project to design a system that measures a 'whole' must define the limits of that 'wholeness' and how those limits are produced (and in this case, are malleable). One might attach every sensor available (and the author has) to the body and attempt to infer the state of the whole from the data (and its cross reference), but what 'whole' does the data represent? Not the whole of the body, but the whole of methods, of techniques of knowing the body. And what of non-physical instruments, used to measure the qualities of experience, meaning and narrative, or the experimental techniques developed by early psychophysiologists to measure variations and norms in human perceptual apparatus. These three approaches describe a taxonomy of techniques that appear to delineate knowledge attainable in different ways, but how can these epistemologies be reconciled?

A wholeness of measuring can exist only in reference to a clearly delineated model of what is measured, it must always name what is excluded or instead make the mistake of assuming that its objects have edges, clarity and identity that are fixed and easy to negotiate. Instruments, like senses, evolve and emerge in response to the world and to the way in which humans shape the world.

In order to incorporate a sense of holism, which moves away from any inner/outer distinction the task is of not only 'dissolving' the language with which this contrast is reinforced; providing an alternative understanding of what subjectivity *is* as material is necessary. The thesis therefore draws on the work of those who have rejected the concept of 'mind' and its terminologies.

Instead, its approach is materialist in the extreme, except that the material of which it speaks is one made unfamiliar by its mutation into something utterly suffused with, constitutive of and responsive to meaning.

The discussion of instrumentation and its relationship with this different conception of the body leads to a more complex consideration of the effects of the way we make knowledge and how human beings understand themselves as producers and products of knowledge. This self making aspect of the body that Grosz describes in the opening quote of this chapter, the body as 'an object, but an object which somehow contains and coexists with an interiority', 'the very stuff of subjectivity' which functions 'interactively and productively' is central to a non-reductive materialist account of the body.

The 'stuff of subjectivity'

In *Volatile Bodies* (1998), Grosz provides a survey of philosophies from the continental tradition that incorporate a notion of embodied subjectivity.[49] The target of her analysis is a general account of non-physicalist materialism that can be applied to understanding the embodiment of female corporeality, 'a refiguring of the body so that it moves from the periphery to the centre of

[49] Grosz's survey of philosophies that reject dualisms and offer insights for a feminist analysis of sexuality includes both Freud and Lacan's psychoanalytic work, Merleau-Ponty's phenomenology, in particular his writing on the 'chiasm' which collapses subjectivity and objectivity in the space of perception (Grosz, 1994, p.96), Nietzsche, Delueze and Guattari and Foucault. Within each she works to move the site of enquiry to the body, which is often found at the edge of the study, or implicit in the ideas of the author (Grosz, 1998).

analysis' (Grosz, 1998, p.ix).

Grosz argues that the prevailing tendency in feminism and in wider culture is to accept the existing dichotomies that prevent a satisfactory understanding of the female body as both a natural and cultural product (Grosz, 1998, p.x). In orientating the relationship of her work to a definition of materialism, she is careful to specify that her project is 'not part of a reductionist endeavour' (Grosz, 1998, p.viii) and that it does not 'involve the abandonment of the terms associated with the subject's psyche or interior'. (Grosz, 1998, p.viii) Instead, against the dichotomies that are implicit in our 'intellectual heritage' and the terminologies that are available – she suggests that 'some kind of understanding of *embodied subjectivity,* of *psychical corporeality,* needs to be developed' (author's emphasis)(Grosz, 1998, p.22). She describes her position thus:

> It does not claim that notions such as agency, reflection, consciousness – indeed, all the categories of interiority – are unnecessary, useless or wrong or that these terms are capable of ready transcription into other terms. Rather, they can be re-mapped, refigured, in terms of models and paradigms which conceive of subjectivity in terms of the primacy of corporeality, which regard subjectivity on the model not of latency or depth but of surface… I have sought out models and conceptions of corporeality that, while nondualist as well as nonreductionist, remain committed to both a broad, nonphysicalist materialism and an acknowledgement of sexual difference (Grosz, 1994, p.viii).

Her reference to a 'nonphysicalist materialism' (Grosz, 1998, p.viii) ensures our awareness that the concept of the body that she is committed to is not a primarily scientific one. While she does not reject the various accounts of the body that biomedicine and other scientific practices inspire, these are not considered sufficient to explain their own effect upon the bodies that they represent. It is for this reason that Grosz rejects the attachment of scientific physics to her concept of materialism that is suggested by the term 'physicalism'.

Ronald Schleifer similarly writes about a 'materialism beyond physicalism' but from the perspective of semiotics and its relationship with the body (2009, p.11). Schleifer's project is to provide a materialist account of human language that reincorporates its neglected materiality and in the author's words: 'create an account of language and discourse that avoids the opposition between matter and spirit' (p.xix). His proposal is to create an account of language 'as a whole' (p.xxii). This exploration of wholeness is intended in a very similar way to Grosz's, to open up:

> [...] ways of imagining phenomenology to be part of all these [material] things, to be, despite its seeming experiential subjectivity – or precisely *in* its seeming experiential subjectivity – a material phenomenon itself (p.xxiii).

Interior, phenomenal experience, language, speech, are all here collapsed into the material body, accepted as not only a real, but a pervasive aspect of physical and material human life.

Schleifer's work provides a number of examples to suggest that meaning and language can be seen as physical and material articulations. He weaves rich descriptions of bodily phenomena - which resist a fixed categorization into natural (bodily, reflexive, organic) or cultural (cognitive, intentional, rational) in an exploration of certain points of contact between the body and meaning. The result is a set of signposts and evidence that demonstrate the inextricably material nature of meaning. Schleifer's materialism is conceived through the evidence posed by the structured analysis of the world, through law-like scientific structures such as the periodic table, which has enabled the prediction of certain aspects of the world, such as new elements, from the existing structures of observation that are in place (p.11). These models, which describe the world, structure our understanding of the material world and constitute knowledge of its states and forms, however, they do not refer to particular instances of the world, but are instead knowledge which is situated 'at one remove' (p.11). He draws on Russell's *The Analysis of Matter* to suggest, as Russell does, that 'matter is best conceived as an "event" rather than as substance' (p.11). This is what Schleifer calls an 'unvisualizable materialism' the 'external psychic' (p.12).

To contextualise his notion of a materialism that can incorporate embodied meaning, Schleifer argues for the necessity of a 'non-reductive materialism'. He argues that the intangibility of a phenomenon does not preclude its material manifestation. His aim is to:

> [...] situate all the activities of literary attention – its sensuousness, its constant recognition of our situation in the world, and its creation and instantiation of layers of meaning for cognition and experience – within a materialist understanding of the world and of experience and to provide sense of the ways that the activities of literature can clarify and perhaps expand what we mean by materialism (Schleifer, 2009, p.xix).

Schleifer also uses Tourette's syndrome as an example[50] of a disorder in which 'the materialities and meaning of discourse are bound together' (p.81) – partway between 'meaningless jerks and noises' and 'meaningful utterances' (p.81) – and which demonstrates the 'very materiality of language'. Schleifer establishes this materiality is established in distinction with the Cartesian notion of language as the evidence of a logical cogito. His account introduces evidence from evolutionary neuroscience, clinical cases like those reported by Oliver Sachs and structural semiotics, to stress the relationship between emotional, haptic utterances and spoken language.

Schleifer refers to Oliver Sach's essays about Tourette's patients where he has discussed the melodic and rhyming qualities of verbal tics which Tourette's patients suffer, with which he draws a comparison with the way in which poetry uses 'rhymes', 'alliteration', 'melody' as a 'resource'. What Tourette's syndrome renders visible 'is the continuity it presents between motor and verbal activity' (p.80). These continuities are exploited by poetry, what Schleifer describes as the 'primitive resources of language' (p.84). He draws attention to research which argues that there are 'tight connections between motor activity and language skills' (p.81) and quotes F.A. Middleton and P.L. Strick's arguments which favour a revision of the popular view that the 'cerebellum and basal ganglia' are 'purely motor structures,' instead arguing

[50] Here it would be prudent to reiterate Schliefer's instance that his account is not intended to 'romanticize'(p.90) Tourette syndrome, and his reminder that it is a serious and distressing illness (p.74).

that they are involved in 'cognitive processes'.

Schleifer (2009) is clear that his account stands against the Cartesian model in which language is the capacity and privilege of the rational subject, the expression of an immaterial and logical mind (p.86). His claim, based on Greimas' account of poetry through evolutionary theory and semiotics (p.84-5), is that poetic language is not only first order articulation that can be thought of as 'primal cries'[51] – as a material signifier – but at the same time this material signifier points at what he calls 'an immaterial signifier constituting an irreducible whole', 'a kind of intangible material substance, like gesture, pointing towards something' (p.87).

The meaning response

In chapter 6 the thesis will use the example of a phenomenon known as the 'placebo effect'. It will examine some episodes in the early history of medical experimentation, these offer a context in which to explore the way in which the notion of the 'imagination' as a biologically active force has been divorced from the practice of medicine by the design of an instrumental test,

[51] He adopts the term 'primal cry' from Nietzsche's account of tragic poetry (1993), alongside this, he also cites evidence from evolutionary neuroscience and neuroscientific studies which demonstrate that Tourette tics are not limited to frontal lobe activity associated with language, and that it is in fact 'midbrain and limbic structures' (evolutionarily speaking older parts of the brain) that are associated with swearing and emotional outbursts, the 'obscene' offering a between a highly material and evolutionarily fundamental part of the human organism, and the meaningful nature of obscene utterances (p.91).

the controlled trial.

The placebo effect has been of interest to scholars in medical anthropology. Daniel Moerman (2002) suggests that the effect is an example of the interplay of two realms, biology and culture, that are often separated across disciplinary boundaries. The discourse of doubt regarding the reality of the placebo effect, that meaning might have genuine biological effects, and the idea that it is a medical paradox, is an example of the way in which the symbolic and meaningful are habitually discounted as being potentially biologically active. Medical anthropology's interest in other medical cultures offer numerous examples of people using unproven medical methods, witchcraft, and systems of understanding the body that are at odds with western allopathic medicine, and which contemporary anthropologists attempt to account for without dismissing them as ignorant or superstitious.[52]

Concerned with offering an account of the other on its own terms, anthropologists have become have developed more holistic accounts of what symbolic human actions – especially those that have medical intentions – might mean in practical terms. The example provided by the placebo effect is particularly useful as it shows what the symbolic has come to mean in orthodox contemporary medical science, the science that informs the use of instrumental interventions on the body. It highlights the persistence of a

[52] This theme will be returned to in the final chapter of the thesis which aims to discuss instrumental poetics, where the notion of 'instrumental pluralism' will be discussed, as an issue which has arisen for anthropology in its understanding of other cultures apparently instrumentally intended actions – such as healing rituals.

history of enlightenment materialism, and a mechanistic account of the body which when reconstructed as a frame for the effects of placebo, reconstitutes an apparently palliative and harmless cure into a misunderstood paradox.

Moerman's survey discusses the placebo effect as it manifests in a variety of contexts, both in controlled tests and in a range of medical treatments – some intentional shams – such as 'placebo surgery', and some involving the long efficacy and use of treatments which appear to have little causal relationship with their effects, such as the use of nitroglycerine to treat angina (p.55-66).

In chapter 6 of the thesis, this history of the placebo effect will be discussed in more detail, in the particular context of the controlled medical trial and the way in which the healing responses of placebo groups in these trials has been understood and described. Within these trials, many factors may cause improvement in patients, regression to the mean, bias, etc. These are what might be thought of as the 'discarded causes' of changes in the body, be they positive healing effects (placebo) or negative (nocebo). Within this group of coincident, and very difficult to separate phenomena, are those aspects of placebo that Moerman refers to as 'the meaning response'. An example of this is the response to the color and form of treatments such as tablets. de Craen et al. (1996) reviewed a number of placebo trials to test the effects of different coloured tablets on test subjects in placebo groups in clinical trials. They found that there was pronounced dispositions to associate particular color with particular effects and for changes in physiology to follow these effects.

Moerman defines as this broader concept of a 'meaning response' as 'The psychological and physiological effects of meaning in the treatment of illness' (p.14). He is careful to clarify its relation to, and distinction from the placebo effect known from clinical trials:

> The meaning response includes most of the things which have traditionally been called the placebo effect [...] it [also] includes many things that are *not* part of the placebo effect as traditionally understood (p.14-15).

Drawing on anthropological, sociological and medical studies, Moerman (2002) collates numerous other known examples of the human body's response to meaning found outside of the medical context. He cites an example of functional blindness experienced by Cambodian women. These women, who have lost the power of sight without any medically observable physical damage to their visual system, were forced to watch the torture of their families by the Khmer Rouge and were described as having 'cried until they could not see' (p.133-4). Another study, of people of Chinese descent and traditional beliefs living in California (p78-9), showed a correlation between their likelihood to die of certain causes depending on the nature of their birth planet (determined by time and year of birth) and their level of belief in these traditional systems.

Anthropology and the 'meaning response'

There are many other examples of these kinds of culturally inflected, but bodily phenomena, which have been recorded by anthropologists. One well-known example is that of the experience and symptoms of menopause observed by Margaret Lock. Lock's (1993) quantitative, and comparative study of North American and Japanese women's experience of menopause led her to argue that:

> Without question similar endocrinological[53] changes are implicated in both cases, [both cultures] yet these changes are sufficiently unlike so as to substantially influence subjective experience. Thus differing accounts of biological aging are not simply the result of culturally shaped experiences of a universal physical experience but the products, in Japan and North America alike, of an ongoing dialectic between biology and culture in which both are contingent (Lock, 1993, p.xx-xxi).

Like Moerman, Lock is concerned with the;

> [...] interdisciplinary struggle over the signifying process itself, in that the units used for analysis – how the body is classified, framed, measured, or segmented in order to explain it – generate debate and argument [...]

In the context of the body this struggle is divided between biomedical science, psychology, and psychiatry and subsections of sociology and anthropology all of which have 'objective methods' but differing models of the body (Lock, 1993, p.xxii).

> [...] knowledge produced in one discipline is virtually ignored in others, which selectively plunder, ignore, or actively dismiss subjective accounts as invalid. This situation becomes infinitely more complex in geographical settings where the Western scientific tradition has been imported and grafted onto local knowledge, scientific and popular as well (Lock, 1993, p.xxii).

[53] Endocrinology is the study of hormonal change and regulation in the body.

As we have seen placebo responses in controlled trials are constituted by a range of phenomena and can be understood to be the effects of a number of interrelated influences upon the process of medical consultation, examination and treatment. In addition to the phenomena attached to controlled testing, there appears to be a group of determinants that Moerman has included within his anthropologically based notion of the meaning response. These he characterizes as the patient's response to meaning and symbol, expressed through biology.

The body in a 'flat ontology'

Bruno Latour (1999) has pointed out that 'matter is not a given but a recent historical creation' (p.207). It is this that he refers to as 'the symbolic' (p.xiii) the realm that Schleifer's project works to give back its materiality. Latour argues that it is a legacy of modernism that the 'complex genealogy' of matter, which is not 'primitive, immutable or ahistorical' but instead a 'package of former crossovers between social and natural elements' (p.xiii) is so often disregarded. The understanding that the material world cannot be considered as primitive, immutable, or prior to human knowledge has been investigated by many scholarly disciplines, as the discussion of Grosz and Schleifer's projects above suggests. Sociologists of Science, Anthropologists and Feminist scholars, have often, following the continental traditions of thought discussed earlier in the chapter, resisted in different ways the modernist tendencies that Latour describes above. The body in particular has served as a site of resistance in these discourses, particularly feminism, which stresses the dual cultural and biological production of the body.

What Latour describes might be termed a 'flat ontology', and offers an alternative structure in which to think about the body. This ontology is one in which, as Graham Harman puts it 'atoms have no more reality that grain markets or sports franchises' (Harman, 2008, p.370). In a 'flat ontology', the understanding of instruments as depicting, measuring or representing states of human bodies which might usually be considered internal or subjective can no longer be considered as constrained by ontological limitations, only methodological ones. Thus the thesis takes a materialist position, but one that is non-reductive. By describing bodies and instruments in this way, the thesis is then able to investigate the possibilities of this approach for a creative concept of instrumentation.

The concept of a flat ontology offers a transformative break away from the previous scepticism that pervades models of perception, knowledge, the establishment of truth. It offers a philosophy that is based *in* the world and does not include a scepticism relating to knowledge of that world. As Harman describes it, this 'Philosophy is not concerned with human access to the world, but the world itself' (Harman, 2008, p370). Following Harman's lead, we are no longer, like Rorty or Wittgenstein, worried about how accurate our descriptions of the world are, we are worried about how 'good' they are[54], and because a description might serve many purposes, and because of its leanings and tendencies, describe and delineate many different things, how 'good' a description may be, and essentially, what it is of, is a constantly moving target.

Summary: A 'flat ontology' of bodies and instrumentation

This chapter has established a number of points and definitions regarding the relationship between subjectivity, meaning and the material body. It has also begun to show how this discussion links to a consideration of the scientific epistemologies that explain why instrumental sensors are useful, a discussion that will be further extended in the next chapter.

The gestalt notion of the body that underlies the argument of the thesis has now been clarified. The chapter has given examples of a range of scholarship that has developed a notion of a subjectivity that pervades human bodies. The concept of subjectivity that this chapter discusses is not one of specific consciousness but the notion of the individuated and personal subject as the internal meaning of a physical body, the discursive and symbolic dimension of the body. The borders of this subjectivity, unlike that of Kantian subjective consciousness, are permeable and unbounded; they can flow and be broken, as meaning moves from one place to another.

The various accounts of the body found in the work of the philosophers

[54] The question of how to assess the 'goodness' of descriptions, features strongly in Rorty's philosophy that (through an extension of Dewey and Quine), produces what Rorty calls 'neopragmatism' (Rorty, 1980).

discussed in this chapter describe how embodied aspects of emotion, feeling, experience, perception, cognition and consciousness might all be considered as materially manifest in the body. It does this so that the air is cleared to examine the notion of instrumental measurement of new aspects of the body. It does not do this because it appears to be something easy, clearly many things that are thought of a 'mental' are amorphous, they may be as Schleifer suggests, not substances, but events. Other aspects of the 'private or interior' are however, so patently obvious (as Wittgenstein points out) there is no reason to consider them as mental attributes inaccessible to material instrumentation.

The human body, taken as a whole, as a gestalt human being, is not something that can be conceived of to sit inertly beneath a device, be that one human body, or the larger concept of the human which scientific measurement contributes to. Self awareness, and a definition of that self, reinforced, represented and explored through devices, is central to understanding how instruments can be elements in any creative project, that they can be used not in the terms with which they come ready equipped, but that they can be used as a practice.

The chapter, through its discussion of Rorty's rejection of the mind-body problem and an overview of the formation of the concept of a distinct mental realm alongside Wittgenstein, Grosz and Schleifer's revisions of what is considered materially manifest as aspects of the subjective body gives the thesis a basis for its account of the human body. In this it is intended to give a sense of how the body may be held to be a material manifestation of the experiential and the material, and how this account offers an alternative to a dualistic or reductive approach to the traditionally immaterial aspects of human subjective experience, meaning, and as Latour would describe it, the symbolic. This account of the body is intended to underpin the thesis' discussion of the way in which the body can be understood to interact with sensing technology.

The question is not about what is physical or mental, but about what technological structures might be invented that could evoke certain aspects of embodied life. One of the aims of this chapter was to break down some of the existing categories that tend to invade discussions of what is materially manifest. It shows the philosophical histories that have given rise to these concepts, as well as fleshes out accounts of the body that might give a sense of the alternatives to the effects of a persistent, if faded, Cartesian ontology.

The thesis will now go on to introduce and historicise a concept of instrumentation, in its classical formulation in philosophy of science as an epistemological apparatus. Historically, the rationale of scientific epistemology (which was also adopted by supporters of instrumental technologies in medicine) has considered instrumentation to be a way in which to countermand the troublesome effects of individual subjectivity on the pursuit of scientific truth. In order to understand this concept of instrumentation's privileged link with physical reality, Chapter 2 will embark on a discussion of scientific and mechanical objectivity. It will extend Chapter 1 by offering a complementary perspective on the dualistic way in which scientific instrumentation is understood as an epistemological tool, serving to complete the thesis' account of the initial problem regarding the relationship between 'objective instruments' and 'gestalt bodies'.

Chapter 2. Mechanical Objectivity

Chapter 2 will explore the theme of scientific epistemology, scepticism and the role of instrumentation in more detail. It will focus particularly on historical explanations of the way in which instrumental measurement interfaces with reality. Chapter 1 gave an overview of the way in which a tradition of mind-body philosophy has influenced how the ontology of the human body is conceptualised. The history of the mind-body problem was introduced in the context of Richard Rorty's philosophical critique. His argument is that the problem is the contingent product of a form of 'epistemological scepticism' that questions human access to the physical world (and hence knowledge of its objects). Chapter 2 retains this theme of epistemological scepticism, and charts the influence of this idea on how scientific instrumentation is understood. In doing this, the chapter extends the themes of Chapter 1 but with an alternate emphasis on uncovering a history of experimental science.

Chapter 2 aims to show how certain philosophical discourses regarding the nature of the human mind and of physical reality have impacted upon scientific epistemology. These accounts can be seen to support a particular way of understanding instrumentation as an epistemologically privileged way of interacting with the 'real'. The discussion is introduced by a key text in the history of experimental science, Francis Bacon's *Novum Organon* (1900 [1620]) and also makes significant reference to the work of Lorraine Daston and Peter Galison (2007) on the history of the development of scientific objectivity in the 17th and 18th centuries. Drawing on these sources allows Chapter 2 to embark on a discussion of the concept of objectivity and its historical link with instrumentation. It describes the way in which instrumentation has been conceptualised as a scientific tool that enables the overcoming of certain epistemological hurdles. As will be seen, these are partly posed by problems relating to human perception and knowledge, and for the purposes of the following discussion, exemplified by Francis Bacon's 'idols' (1900).

By returning to early and influential philosophical ideas like Bacon's this chapter clarifies how the thesis departs from previous discourse on the nature of instrumentation, to develop a notion of instrumentation as productive. The discussion picks up on some of the themes that were touched on in the closing sections of Chapter 1. For example, this chapter argues that the problems relating to scepticism about what can be reliably known are sometimes linked to a problematic assumption about the world, or 'the real' as a pre-existing and fixed entity that can be accurately depicted (this concept of representation is one that is critiqued in Rorty's PMN). To show how this problem relates to instruments this chapter uncovers the historicity of the notion of an authentic and fixed 'objective' world and its attachment to mechanised instrumentation technologies; it offers a deconstruction of the relationship between machines and the physically authentic, and prepares for the discussion in chapter 3 of the variety of concepts of objectivity which may relate to knowledge of bodies and medical practices.

Instruments and objectivity

In response to the ideas discussed above, one purpose of this chapter is to unpack the idea that instruments are associated with the ability to access a particular 'truth' or reality which is inaccessible to, or clouded by, human senses. As will be discussed, instrumental measurement, from the use of guiding tools such as rulers, to a range of automatic data registration technologies, is understood as a tactic that allows scientists to overcome certain epistemological obstacles. One of these obstacles is the faulty nature of the human senses, and as science has become a collaborative activity, another has been posed by a related problem – that of intersubjectivity[55]. What this section aims to highlight is that the notion of faulty human senses is partly dependent to a particular notion of authentic 'objective' reality that is

[55] Understanding how information can be reliably transferred between two minds – hence – inter-subjectively has historically offered problems for medical instruction. At different times in history, medical diagnosis has been reliant on the perception and categorisation of body states by physicians. At times in history taste, smell, sound (auscultation), touch (pulse taking, palpation and temperature taking) as well as visible clues have all been important 'objective' clues for physicians (Porter, 1999; Reiser, 1993). Kuriyama (1999) notes the problems with pulse diagnosis and the accurate description of 'haptic knowledge' presented by pulse feeling was particularly considered as particularly problematic by European physicians of the mid-eighteenth century. When faced with the prospect of teaching pulse taking, physicians observed the problems of how to communicate accurately to their students the correct interpretations of the sensations at their fingertips (p.67). Kuriyama's study reflects on a difference in epistemological concerns, dating back to Greek thought and the separation of perception from objective reality, to the lack of a similar problem for contemporaneous scholars in China, practicing a comparable diagnostic form, feeling the 'mo', but in a philosophical climate where the relationship of experience to reality was not traditionally problematic (p.78-103).

ahistorical and acultural, which it is the apparent goal of scientific measurement to uncover.

The following section of the chapter will set out this discussion with reference to Francis Bacon's philosophy of scientific experiment, serving to highlight some traditional problems of scientific epistemology which instrumentation and other scientific methods have been enlisted[56] to address. This discussion serves to reveal the conditions in which certain problems in scientific practice are linked to particular philosophical ideas. It shows that within these discourses the notion of objectivity has come to stand for a multitude of solutions in scientific methodology, and to stand in for a number of different values, which if left unexamined could serve to complicate and confuse the discussion of measuring instruments in the later parts of the thesis.

Bacon's discussion of the idols has arguably come to be a 'common sense' view of how scientific experiment operates, and what the role of experiment, instrument, and mechanisation might be. While the idols offer what appears to be a clear analysis of the problems of scientific study, Bacon's arguments invoke a form of epistemological scepticism. His concern is with the untrustworthiness of human perception in the making of scientific

[56] Here one might also say 'invented' rather than 'enlisted', although innovated may be the most appropriate term. In many cases scientists have adopted and adapted the technologies around them for the purposes of making scientific investigations. One example of this is James Joule's 1850 experiments on the relationship between friction and heat for which he used a number of techniques borrowed from the brewing industry (where malts must be heated carefully) (Sibum, 1995).

observations.[57] While the development of automatic measuring technologies did not take place until much later in the history, it, and a number of other methodologies, some of which will be the focus of discussion in the thesis, can be related back to the set of problems which Bacon's discussion defined, and the logic of their development (alongside the changing notions of objectivity and subjectivity which will be discussed below) might be seen signalled in his work.

The Novum Organon; Bacon's identification of the 'Idols'

Philosopher-scientist Francis Bacon's[58] *Novum Organon* or *New Instrument*

[57] It is worth noting that the concept of clear perception is a complex one and space is lacking for a full exposition of this idea. Readers might refer to Steven Shapin's (1988 ; 2010) histories of scientific experiment in mid 18th century Europe which show that the ability to make a trustworthy and accurate scientific observation which would be accepted by the scientific community was at one time more based upon social class than on practical experimental skill (2010, 59-89). See for example his work on Robert Hooke of the Royal Society's role as an engineer and employee rather than a gentleman – and therefore not an experimental philosopher, despite his considerable experimental skill (his contributions to experimental science were often attributed to his employer, Robert Boyle) (2010, p.182-211). It is reasonable to assume, that for Bacon, the link between social position and perceptual acuity and judgment was an issue of common sense.

[58] Bacon is considered to be the forefather of experimental science and is credited with the development of 'experimental' method and the invention of scientific induction. During his lifetime Bacon was a politician (at one point he held the office of High Chancellor of England), philosopher, author (allegedly of Shakespeare's works amongst many others), and lawyer. Bacon's unfinished New Atlantis is considered the first science fiction tale, a utopian story of a voyage to an imaginary city state where the unnamed narrator encounters a community centered around a scientific research centre, Solomon's House. His rendering of this utopian society is held to have been an influence on the formation of the Invisible College, which in 1662 became the Royal Society (Abrahams, 2000, p.1548). Late into the 17th Century Bacon's ideas were held in high esteem by the Royal Society; the members (and employees) of which put Bacon's lofty experimental ideals into practice by developing their own range of laboratory instruments. These both included those intended for measurement and observation, such as the microscope, but also those which allowed

(1860 [1620]) offers a frame for a discussion of how instrumental technologies have been developed by scientists in response to a range of epistemological problems. By looking at Bacon's characterisation of these problems as the 'idols', this section shows how the link between instrumentation as a set of methods and a number of varying problems of scientific epistemology is constituted.

The *Organon* was Bacon's exposition of an inductive and experimental science intended to replace the 'sophistry'[59] of his time, which 'impeded' the proper 'interpretation of nature'. Within it Bacon described a full account of the aspects of human perception and culture that put an undistorted study of nature at risk, and his directions for negotiating these problems. The potential pitfalls that Bacon identified are catalogued under the general name of the 'idols'. All of which can be seen as an analogue to modern notions of subjectivity on the part of experimenters and natural philosophers as a risk to clear knowledge in science, and the justification for a careful form of experimental science which used instrumentation to structure and manage; to make the *object* of scientific study just that, untouched, independent and *objective*

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what Bacon called the 'vexation' of nature, such as the air pump, which created artificial conditions and phenomena (Abrahams, 2000, p.1530)(2). Sprat's *The History of the Royal Society of London* (1667) (published by the society's own press) gives an indication of the high esteem in which Bacon's work was held within the society; 'I shall onely [*sic*] mention one great Man, who had the true Imagination of the whole extent of this Enterprize [*sic*], as it is now set on foot ; and that is, the Lord Bacon. In whose Books that are every where scattered the best arguments, that can be produce'd [*sic*] for the defence of Experimental Philosophy ; and the best directions, that are needful to promote it' (Sprat, 1667, p.35).

[59] The original Organon was Aristotle's text on logic. The New Organon is at least partly dedicated to a critique of the methods of this particular 'sophist'.

of the potentially faulty perceptions of the experimenter.

In the *Organon* Bacon explains this doctrine of idols, the impediments to the philosopher–scientist's clear study of nature. They are those things in the nature of man 'to which we give false worship',[60] the 'psychological dispositions and fears' that prevent progress in the sciences (Abrahams, 2000, p.1530). He names them the Idols of the 'Tribe', 'Cave', 'Market-Place', and 'Theatre' (Bacon, 1860, p.319).

The Tribe refers to the faulty perception of human beings as a race, as he explains, 'the human understanding is like a false mirror, which, receiving rays irregularly, distorts and discolours the nature of things by mingling its own nature with it' (p.77). Alongside this distorting perception, 'the errors common to human nature in general' (p.77), there are also the idols of the Cave or Den, associated with the personal attributes and history of the individual human observer. These amount to the idiosyncrasies of the individual, 'owing to his proper and peculiar nature', 'education', 'conversation with others', 'the reading of books' and the 'authority of those he esteems and admires' (p.77). So Bacon establishes the risks of human perception being prone to error on an individual level, either from the natural dispositions of the perceptual apparatus of the tribe, or the intellectual life knowledge though which perceptions are filtered, what he calls 'the cave'.

[60] Note the moralistic overtones of Bacon's choice of the term 'idol', which he clearly indicates with his reference to 'false worship'. Daston and Galison have commented on the role of morality and its relationship with objectivity in their discussion on development of a 'scientific self'. Here they chart the changing relationships of concepts of moral purity with various epistemological concerns, such as objectivity and self-restraint in observation through the 18th and 19th centuries (2007, p.191-251).

In addition, two further idols, of the Theatre and Market-Place, establish that the concepts shared between humankind in the form of language and culture, and the existing systems and principles by which the natural world is understood, also pose a source of misdirection. The idols of the Theatre, are the tendency of existing theories, philosophies and methods to render sciences 'dogmatic and magisterial' (Bacon, 1860, p.98). Bacon compares them to the theatre because 'all received systems are but so many stage-plays; representing worlds of their own creation after an unreal and scenic fashion' (p.78).

Finally, the idols of the Market-Place 'are the most troublesome of all' (Bacon, 1860, p.86). They are so-named for the 'commerce between men' and which in this market is the commerce of words, discourse. The Idols of the Market-Place creep 'into the understanding through the alliances of words and names'. Words, Bacon tells us, become fixed in meaning, and when we might modify them to more closely represent nature they resist, 'rendering the sciences and philosophy sophistical and inactive'. As he points out; 'The high and formal discussions of learned men end often-times in disputes about words and names' (p.87).

Bacon's catalogue of the possible errors confronting aspiring natural scientists can be seen partly to be intended to offer a strong support for his new systems of experiment and induction, part of an attack on the 'sophistry' that he claimed preceded his intervention. His argument relies upon a demolition of prior knowledge, existing philosophical systems and language that shape the interpretation of new discoveries. However, in addition to this

Bacon argues that even the most fundamental physical aspects of human perception pose problems for clear observations;[61]

> [...] by far the greatest hindrance and aberration of the human understanding proceeds from the dullness, incompetency, and deceptions of the senses; in that things which strike the sense outweigh things which do not immediately strike it, though they be more important. Hence it is that speculation commonly ceases where sight ceases; insomuch that of things invisible there is little or no observation [...] For the sense by itself is a thing infirm and erring; neither can instruments for enlarging or sharpening the senses do much (Bacon, 1860, p.82).

Science in response to the idols

The *Novum Organon* was the second part of a larger project for Bacon, which remained unfinished, to produce a ground from which natural philosophy's 'interpretation of nature' could proceed free from the errors that he had diagnosed. The title, *New Instrument* refers to his now famous development of a notion of scientific induction based on experimental

[61] As Lorraine Daston notes in her essay *Scientific Error and the Ethos of Belief* (2002-2003), other early modern natural philosophers Rene Descartes and John Locke, like Bacon, chose skeptical reduction as a starting point for their enquiries (p.58). The popularity of Bacon's cautionary rigour with the natural philosophers of the Royal Society in the late 17th century signaled a continuing concern in the more general community of natural philosophers with the problem of human error as a hurdle to the investigation of nature. As Daston comments, this period of scientific history was characterised by a 'collective and prolonged epistemological shock' caused by a number of revolutionary discoveries: 'the voyages of discovery, the Reformation, the triumph of Copernican Astronomy and Newtonian natural philosophy, the demonstration of the circulation of the blood' (p.51). The result of this 'dramatic and disturbing' (ibid) realisation for early modern thinkers that so much of the orthodoxy had been at fault for centuries appears to have manifested in an ever present concern with developing a scientific epistemology which could explain and prevent error.

observation. To this end, the *Organon* provides not only epistemological cautions as seen in his taxonomy of the 'idols' - but also a lengthy categorisation and explanation of forms and methods of practical experiment by which empirical observations may be made and recorded. Instruments played an important role in Bacon's suggestions for an experimental science that dealt with the problems of the idols, so linking the use of instrumentation with a concept of the insufficiency of human perception. Bacon's main recommendations for dealing with this problem were to proceed from experiment.

To address the lack of progress in philosophy caused by dogmatism and commitment to old ideas – the idols of the Theatre or Systems, Bacon suggests a number of tools of observation and experiment, he provides:

> [...] a history not only of nature free and large... but much more of nature under constraint and vexed. Therefore I set down at length all experiments of the mechanical arts... the nature of things betrays itself more readily under the vexations of art than in its natural freedom (Bacon, 1860, p.48).

To this end he suggests that aspiring investigators might hunt out experiments from the 'mechanical arts' (technology)[62] that can broaden knowledge of nature by manufacturing states of 'vexation'. As part of his directions for a natural science of reason supported by physical

[62] For a brief history of the changing terminologies and understandings of what is generally at present called technology, David Nye's (2006) introduction in 'Technology Matters; Questions to live with' is recommended.

experimentation Bacon suggests an approach of extreme caution on the part of investigators. He suggests that they go about establishing 'progressive stages of certainty' (p.60).

> There remains but one course for the recovery of a sound and healthy condition – namely, that the entire work of the understanding be commenced afresh, and the mind itself be from the very outset not left to take its own course, but be guided at every step; and the business be done as if by machinery (p.61).

Here Bacon uses the term instrument to indicate both physical tools (an instrument of the hand) and conceptual mechanisms (instrument of the mind). The physical instrumentation he refers to is of two kinds – tools to 'aid the immediate actions of the senses' such as the microscope or telescope – and devices like 'measuring rods, astrolabes and the like, which do not enlarge the sense of sight but rectify and direct it' (Bacon, 1860, p.273). Like the instruments of the mind, these devices sharpen and guide observations. Once reliable sensory data has been obtained, Bacon prescribes a highly cautious and mechanical method for the management of this information, mapping out experimental knowledge as 'tables of discovery' (p.136). This cautious method of building knowledge could then guarantee that natural scientists would arrive at their conclusions inductively rather than allowing their understanding to 'jump and fly from particulars to remote axioms' (p.137).

Instrumentation as a guide for the senses

Despite his cautions regarding the reliability of perception, Bacon states; 'the evidence of the sense, helped and guarded by a certain process of correction, I retain.' (p.60) He then tells us that it is the immediate action of the mind upon the observation that is the more serious risk, the raw senses need to be correctly managed. It is 'the mental operation which follows the act of sense I for the most part reject; and instead of it I open and lay out a new and certain path for the mind to proceed in, starting directly from the simple sensuous perception' (p.61). To this end he introduces instruments as devices that may be used to guide the intellect and the hand in the making of observations;

> Neither the naked hand nor the understanding left to itself can effect much. It is by instruments and helps that the work is done, which are as much wanted for the understanding as for the hand. And as the instruments of the hand either give motion or guide it, so the instruments of the mind supply either suggestions for the understanding or cautions (p.66).

Here, it might be tempting to interpret Bacon's words with the benefit of hindsight, for it is easy to interpret Bacon's ideal for 'recovery' – a mechanisation of 'the understanding' as a historical precursor for contemporary scientific technologies. Bacon's writing clearly communicates a desire for a particular type of perception, uninterpreted and uninfluenced by prior knowledge or theory – in Daston and Galison's words, 'unmarked by prejudice or skill, fantasy or judgement, wishing or striving [...] Objectivity is blind sight, seeing without inference, interpretation, or intelligence' (2007, p.17).

It does appear clear that Bacon's interest in the mechanical collection of information mentioned above indicates that basic strategies for creating this form of 'blind sight' as scientific methodologies were identified long prior to their implementation as mechanised systems of measurement. Bacon's writing also describes a particular rationale for his new doctrine of experiment;

> [...] but all the truer kind of interpretation of nature is effected by instances and experiments fit and apposite; wherein the sense decides touching the experiment only, and the experiment touching the point in nature and the thing itself. (Bacon, 1860, p.82)

Bacon describes the experimental setup as a conduit through which true knowledge can make itself known to the observer's senses, through a careful arrangement of 'experiment' as a connecting path between the 'senses' and 'nature'. Even while his profound scepticism regarding the fallibility of human perception (the tribe), judgement (the cave), and linguistic description (the market-place), long pre-dates the introduction of measuring machinery into laboratory practices, already in the Novum Organon we see Bacon pointing to the notion of an 'experiment touching the point in nature and the thing itself' (ibid). This epistemology which so simply positions physical and empirical systems in contact with nature already begins drawing together the argument which could be later seen in the writings of nineteenth and twentieth century physicians who, as will be discussed in the next section, supported the use of automatic measuring instruments in their clinical practice.

The experiment 'touching' 'the thing itself' is a notion that will be returned to in chapter 4's discussion of the philosophy of instrumentation, in particular Latour and Woolgar's (1978) discussion of scientific instrumentation as 'inscription devices' which they claim are understood by scientific experimenters to make transformations (or transductions) from a 'piece of matter' (the thing itself) to an inscription, a permanent mark, or record.

Centuries later, contemporary devices which automatically register data, from early graphing devices, seismograph, plethysmograph, to computerised data logging, appear to do just what Bacon intended, recording observations 'as if by machinery'[63]. In Bacon's ideas we can see what may be the seed of the desire for (or the eventual justification of a set of technologies which could be understood as providing) mechanical objectivity. However it was much later that certain philosophical and social imperatives made the use and development of mechanised data registration techniques a necessity for scientists (Daston and Galison, 2007). The general move amongst scientists toward the achievement of 'blind sight'; objectivity as understood in the contemporary era, took place in the mid 19th century (2007, p.17; p.42).

Daston and Galison suggest a number of reasons for the mid-19th century push to develop and use these types of technologies, some of which

[63] However it is worth noting that Bacon is talking about instruments that are used as 'guides' for observation, and because the role of instruments as 'guides' only remained as such until the 17th century, as previously noted, (36) a far greater concern for scientists was the debate regarding whether the individual attributes of the observer who made them qualified them as a reliable witness.

will be discussed in the next chapter in more detail (2007, p.17). One of these, which related to mechanical objectivity, was the desire to remove the observer entirely – 'aperspectival' objectivity (Daston, 1992a) (which actively denies the 'subjective' position of the observer) was also unknown until the 19th century. Prior to this time, the notion of being a skilled and trained observer, who could perceive the truth of nature and represent it, had far more influence on how natural scientists thought about their practices and the problems of scientific work.

Mechanical objectivity and 'blind sight'

The kind of behaviours, mode of conduct, and methods of observation, which are described in contemporary scientific culture as 'objective' are a relatively recent invention. Some of the problems that these methods are designed to counter are within Bacon's original diagnosis of the idols. However, whilst prior to the popularisation of a modern notion of the term these issues were noted as problems by scientists and physicians, without the problematic complexity that accompanies the modern incarnation of the concept of objectivity. For the scientists of the 19th century, measuring instruments, particularly those that used photographic technologies and other graphical means to record information came to be considered the exemplar of objectivity. The concept of disinterested and mechanistic approaches to the collection of reliable data led to the development of a range of technologies by the scientists of the time such as drawing grids, measuring tools, lab notebooks (Daston, 2007, p.38-9). The pursuit of metrological standards and best practice in the performance of measurement was reinvented as what can be described as a moral imperative for scientific practitioners (p.39-40).

This concept of the objectivity of machines, described by Theodore M. Porter (1996), Peter Galison (1998) and Daston and Galison (2007) as 'mechanical objectivity' has had changing fortunes. Galison (1998) chronicles the rise of the particularly mechanical notion of objectivity to a period after 1830, when;

> [...] both the persona of the natural philosopher and the status of pictorial representations of nature shifted. Instead of a transcendental Genius improving or idealizing nature, the desired character of the natural philosopher inverted to one of self-abnegation, Instead of truth to nature, these scientists aspired to let nature 'speak for itself' through a set of instrumentalities that minimized intervention, hamstrung interpretation, and blocked artistic licence (Galison, 1998, p.328-9).

This notion of the mechanical was, for Galison, a form that had 'nothing to do with truth, and nothing to do with the establishment of certainty' (p.331). Mechanical objectivity was instead, shaped by a;

> [...] machine ideal: the machine as a neutral and transparent operator that would serve both as instrument of registration without intervention *and* as an ideal for the moral discipline of the scientists themselves. Objectivity was that which remained when the earlier values of the subjective, interpretative, and artistic were banished (p.332).

Galison's history charts the changes in how scientific atlas makers in diverse scientific fields such as 'topographical and sectional anatomy', 'encephalography' and 'stellar spectra' (p.332-8) described their methodology for the production of the collections of images within their atlases. The 'machine ideal' was considered exemplary for the acquisition of data and the creation of scientific images, and was greatly in favour with the scientists of the 'last two thirds of the nineteenth century'. Galison also charts the later turn away from eighteenth-century mechanical objectivity by the atlas makers of the early twentieth century (p.334), towards a culture of 'trained judgement'. However, he notes, and this sentiment is reiterated in his later collaborative study with Lorraine Daston (2007), that these changes in view were not comprehensive across all sciences or historical periods. Instead it is more accurate to understand the attitudes toward objectivity and the methods that count towards it, the variety of 'epistemic virtues' (Daston and Galison, 2007, p.41) as ideas and practices that work in 'parallel and overlap', and while newer ideas 'inevitably' modify the existing ones, they often coexist (ibid).

Mechanical objectivity was central to scientific work from the mid-nineteenth century to the early twentieth. While as a central concern for scientists, it was relatively short-lived, however as a concept relating to automatic machine registration, it persists. In practice, mechanical objectivity has been joined by other concepts of objective reason, such as trained judgement, which stresses the importance of expert knowledge and experience in the reading and analysis of scientific data and documents of 'judgement and interpretation' (Galison, 1998, p.332). Central to Daston and Galison's (2007) history is the understanding that that the different epistemological periods and virtues they identify are interleaved and coexist even in contemporary scientific practices, but what is crucial for the thesis is that the move away from mechanical objectivity was based on an understanding of the importance of subjective interpretation on the part of the scientist, interpretation necessary in order to construct and recognise scientific knowledge. In distinction, the notion of a mechanical objectivity as it might be seen as an attribute of the instrument, as a physical and mechanical device that when used to interact with the material world around it will produce documents that are, because of their machine-like rendering of reality, sometimes inscrutable to any interpreter but the trained eye of the expert, remains intact. This is not to attribute a human form of knowledge to devices, but to question their relation with the rest of physical reality as being a one-way path, through which they translate phenomena into marks, but leave that reality unmodified.

The concept of objectivity

The reason that these different understandings of objectivity raise a potential problem in the thesis is that, as Ted Porter notes, 'objectivity is nearly synonymous with realism' (1996, p.3). Traditionally the positivist tradition in the philosophy and history of science has led to the notion of objectivity being accepted uncritically as a boon for any study, medical, historical or social (p.4). He identifies 'absolute objectivity', 'disciplinary objectivity' and 'mechanical objectivity' as distinct uses of the concept which have emerged at different times and been considered important by different groups (p.3-4). 'When philosophers speak of the objectivity of science, they generally speak of its ability to know things as they really are' (p.3). It is a relatively recent movement in the historical and science studies literature in which notions such as the usefulness of mathematical measurements, and of studying the quantifiable and the objective have been questioned.[64]

In line with this move to re-examine the claims to reality made by scientific practices, Daston and Galison (2007) point out that 'scientific objectivity has a history' (2007, 17), and that;

> All sides of these several debates have largely assumed that objectivity is and has been a monolithic and immutable concept, at least since the seventeenth century. So pervasive and apparently persuasive is this assumption that it is rarely even uttered [...] the implication is that objectivity itself has no history (Daston, 2002, p.598.)

On charting this history, Daston and Galison (2007) show that in the practice and philosophy of science, objectivity represents a group of ideas rather than a singular concept. They examine the development of the word 'objective', which, while always the antonym of subjectivity, underwent – at the hands of Immanuel Kant and his interpreters – rescue from relative obscurity and a dramatic reversal in meaning.[65] As Daston and Galison show, through its redefinition by Kantian philosophy and following adoption by the sciences,

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[64] This shift is the result of a number of factors, one of which is the influential work of historian T.H.Kuhn (1970), which began to inspire those in the social sciences and history to revisit and question some of the assumptions underlying the story by which science explained itself.

[65] They chart the development of the two terms (Daston and Galison, 2007, p.29).

objectivity has come to mix the moral and practical imperatives of what would be understood to constitute good scientific practice. As they explain;

> Conceptually it operates by synecdoche, making this or that aspect of objectivity stand for the whole, and on an ad hoc basis. The criterion may be emotional detachment in one case; automatic procedures for registering data in another; recourse to quantification in still another; belief in a bedrock reality independent of human observers in yet another. In this fashion, it is not difficult to tote up a long list of forerunners of objectivity [...] The aim of a non-teleological history of scientific objectivity must be to show how all these elements came to be fused together (it is not self-evident, for example, what emotional detachment has to do with automatic data registration), designated by a single work, and translated into specific scientific techniques. (Daston and Galison, 2007, p.29)[*original italics*].

This mixture of practices and imperatives in which 'certain parts come to stand for the whole' result in technical practices such as 'automatic data registration' being linked with methodological strategies such as 'emotional detachment' and philosophical ideas like 'belief in a bedrock reality independent of human observers'. The effect of this is a confusion regarding how instrumentation can be understood in a philosophical context that does not marginalize the role of the human observer. This chapter clarifies and disables this confusion by reflecting on work of scholars who have gone about disentangling the discourse, from different vantages; historical, such as Daston and Galison (2007) and philosophical, by returning to Richard Rorty's (1980) work. While measurement technologies are useful because they are *objective*, many different interpretations can be made of what this statement means.

The thing itself, mechanical objectivity in medical science

In medical science, the rationale of mechanical objectivity persists. It can be detected both in the way in which physicians make use of a combination of scientific technologies and rational analysis to arrive at diagnosis, (Saunders, 2008) and also the idea that imaging technologies can be used to render the human body visible and transparent, to diagnose, and record. Diagnostic devices, imaging machines, electrophysiological sensors, chemical analyses, genetic testing, are among the high tech methods by which human bodies become the subjects of data collection or image making practices. It is not the aim of this thesis to examine in particular any of these methods, the claims of their users, or comment particularly on the way in which they each individually represent human bodies (in terms of the documents and evidence which they produce).[66] The concern of this thesis is with a somewhat more elusive notion, the idea that instrumental devices are not only a form of representation, but of production, which may be exploited by creative practices which incorporate instrumentation.

The contrasting ways in which we can understand how instruments represent the 'reality of the body' or 'things themselves' is exemplified by the following contrasting descriptions of two types of medical instrumentation. Consider physician Thomas Lewis' (1920) observation on the advantages of

[66] A selection of recent literature which examines medical technologies and the discourses, both social and scientific, surrounding their production of images and bodily categories are Joseph Dumit's *Picturing Personhood* (2004) and Joyce's (2008) studies of FMRI scanning as well as Saunder's (2008) text on CT (Computed Tomography) Scanning.

the electrocardiograph made in the introduction to his *The Mechanism and Graphic Registration of the Heart Beat*;

> The records in themselves constitute the most exact signs of cardiac affections which we possess. Imprinted by the disease itself they form permanent and unquestionable testimony of events which occurred [...] (Lewis, 1920, p.ix).

Lewis's claim that the 'records' made by the electrocardiograph 'in themselves' 'constitute the most exact signs' of 'events which occurred' demonstrates the persuasive influence of mechanical objectivity as claimed on behalf of a mechanical system. The apparatus becomes transparent, a conduit for the actions of 'the disease itself'. This description is little different from Henry Fox Talbot's description of the photographic process of the calotype as 'sun pictures' made by 'the pencil of nature' in his 1844 book of that name. Within visual studies scholarship surrounding photographic technologies, the naïveté which seemingly persists in discourses surrounding novel technologies has long been replaced by more sophisticated and critical approaches to the role of mechanical apparatus in the production of imagery. As Roland Barthes' (1980) observed, the photograph appears to operate as a transparent package for what it depicts, the photograph is always pointing away from itself as an object. The apparatus, and the work that it does, becomes transparent.

Lewis's description of instrumentation is characteristic of the textbook view of scientific instruments adopted by medical science in the late 19th and early 20th century (Reiser, 1981, p.162), which takes an uncritical stance towards the representation of entities by medical devices and diagnostic methods, eager to adopt objective methods of diagnosis in order to avoid the error prone 'subjectivity' of both the patient, and the physician.

Statements of this kind still persist in contemporary medical imaging discourses where this rhetoric of transparency and precision is central to the popular narratives that surround medical imaging practices. Joyce's (2009) sociological study of magnetic resonance imaging practices leads her to observe that;

> Believed to be precise and indefatigable, machines are highly valued in knowledge production. In contrast, the human, positioned as fallible and biased, is transformed into a suspicious figure. The attribution of precision to mechanical reproduction produces a halo of certainty around machine-produced information; numbers, graphs and anatomical pictures all benefit from this shared belief (p.52).

This positioning of the machine as independent producer of data or images, as Joyce observes, operates to render 'invisible' the human work, negotiation and decision making that is required to produce usable outputs from instrumental technologies.[67] This can be seen as a rhetorical strategy that reinforces the authority of medical interpretations and diagnosis. One effect of this pervasive attitude towards these machines is that responsibility for production and interpretation of evidence is transferred from medical and research staff to machines that are considered to be essentially automatic

[67] These aspects of the technical work required to produce images which are obfuscated by their representation as objective, mechanically produced, texts is discussed in detail by Dumit (2004) and Joyce (2009).

(Joyce, 2009, pp.48-9).

There is a particular aspect of this strategy of deferment to machines that only appears rational if there is a fixed reality for instrumentation to interface with. As Joyce points out 'narratives about MRI examinations are saturated with the notions that they represent unmediated access to a body that exists outside of language and human actions and that they provide definitive answers about a person's physical condition' (Joyce, 2009; p.53). Thus Lewis's statements about the 'unquestionable testimony' of the 'disease itself' can be seen to link with a notion of access to an authentic reality. Whilst physicians, technicians and research scientists using body imaging technologies are well aware of the work that goes into the production of images, they are generally resolutely realist about the physical provenance and connections between the output of instruments and the phenomena with which they are associated. It is not the aim of the thesis to develop a counter argument to this position, but by discussing it, the thesis aims to point out that the representations produced by instrumental apparatuses are ones among many possibilities, and that the apparent objectivity and attachment of devices to a concept of reality 'as it really is', overshadows the possible renegotiation of these representations as well as the further, and more crucial point, that these representations influence the body itself, and can be seen as part of it. One effect of having a 'thing in itself' that instruments might interact with, is that it prevents us from considering that alternatives to what is made visible by the technologies we are using.

To further examine this claim, an alternative understanding of how medical imaging technologies interact with the world can be seen in feminist and science studies theorist Karen Barad's description of ultrasound technology;

> [...] the [piezoelectric] transducer does not allow us to peer innocently at the fetus, nor does it simply offer constraints on what we can see; rather, helps produce and is part of the body it images. That is, the marks on the computer screen (the sonogram images, sonic diffraction patterns translated into an electronic image) refer to a *phenomenon* that is constituted in the intra-action of the 'object' (commonly referred to as the 'fetus') and the 'agencies of observation' (Barad, 2007, p.202).

Barad makes a somewhat different claim to that of Lewis, this time on behalf of another piece of medical technology, the piezoelectric transducer used in the probe of an ultrasound machine. Her discussion of this element of the apparatus of obstetric ultrasound serves as an illustration of her philosophy of scientific measurement. Barad argues that the foetus is a phenomenon *produced* by the act of observation. The apparatus that does this cannot be reduced to an 'idealised observing instrument' (p.202), but something which materializes the phenomena of the foetus through 'an open (but nonarbitrary) temporal process' (p.301).

The difference between Lewis's and Barad's descriptions of these devices of course reflect their own pragmatic needs from a description of the apparatus. Barad's work aims to interrogate ultrasound imaging and the values implicit in the way in which the technology manifests its phenomena. In contrast, it may be that Lewis' realist perspective on the information produced by the electrocardiograph, and his rhetoric regarding its relationship to the 'disease itself' is necessary because of the machine's function in medical diagnosis, there is a pragmatic value in taking the machine at 'face value'[68]. It makes sense for a physician to take a matter-of-fact approach to the entities that are manifested by the instrumental tools that offer a way to obtain information about them, and the bodies of the sick.

At the same time, Barad, and the many other scholars like her who count Michel Foucault amongst their intellectual heritage, are concerned not with the use of medical technology as a means to a particular instrumental end – pragmatically deciding a treatment route, assessing risk. To do so is to neglect the way in which technologies form part of a discursive dimension that shape human bodies and human subjectivities, a dimension which cannot be separated from 'legal, educational, hospital, medical, architectural, military, industrial, and state apparatuses' and their 'disciplinary' effects (Barad, 2007, p.204).

Through the argument of the thesis, it should become apparent, that instruments can be seen to have a formative influence on human bodies. Following the ideas of scholars like Barad, it will stress that those effects are part of how instruments operate in the world, and are not effects that should be considered as unimportant epiphenomena, but can be seen as central to how medical practices are understood. These understandings can help to

[68] The placebo effect has been recorded as being influenced by the belief of doctors in the treatements they prescribe, as well as patients (Moerman, 2003).

inform the use of instrumentation in practices outside of scientific research and medicine.

Summary

As we have seen, historically, the perceived need to reform natural science in response to the threat of error led thinkers like Francis Bacon to propose new methods, starting points and distinctions for the emerging discipline of natural philosophy. In retrospect, it might be easy to conclude that scientists making use of Bacon's ideas were concerned with avoiding the risks to a true account of nature through the application of what we would understand to be scientific objectivity. However, as Daston and Galison (2007) suggest, it was only in Kant's philosophy that a relationship was established between the idea that there was a set of scientific methods that could provide reliable evidence allowing the notion of an underlying true and objective nature to be established.

This construction of, and disconnection between, the 'objective' external and physical world, and the internal, transcendental subject was the result of the philosophical system devised by Kant and his contemporaries and critiqued in *PMN* by Rorty (1980). This separation provides the final part of the story that takes the argument of the last two chapters from discussions of the mind-body problem, to the concept of two separable orders of thing. Kant's philosophy proposed that not only was there an internal, experiencing, knowing and rational subject, but that there was also an external, physical and objective world, independent of that rational subject.

This division is what, in philosophy, is sometimes used to explain why mechanical instruments are useful for rational, 'objective' observations. However, if the essential separation between subject and the world that Kant proposed is denied, and an alternative relationship established, there remains many reasons that mechanical registering instrumentation is useful to scientific and medical practices. These will be addressed in more detail in the next chapter, which further examines the circumstances of the 19^{th} century adoption of mechanical instrumentation into medicine.

The turn towards scepticism in the 17th century can certainly be seen as a motivating factor for the adoption of devices used for instrumental measurement. In the forms of both instruments of the mind and hand, the concept of mechanistic authenticity could now be considered as part of a set of factors which motivated the adoption and development of instrumental technologies as part of the wider technological development of empiricism. Measurement and managed laboratory arrangements, double-blind experiments, are all technologies developed by natural scientists to address the problems relating to the various idols which might otherwise block the path towards a true understanding of nature.

A methodological problem, relating to what is measurable and what is not, and how measurements and standards can be agreed and shared, through this discussion has been shown to be related (partly by synecdoche) to a set of ideas whereby the difference between the internal and perceptual and the external and objective are differentiated. By designating an a priori difference between things subjective and things objective, an argument might be made that there is something fundamental to the ontology of instrumentation that links it to truth making. The aim of this chapter was to show that this apparently fundamental aspect of machines is actually the result of a specific philosophical problem raised by a distancing of human senses from knowledge, in essence the mind from the body, and in effect a distancing of the mind from the world. These incisions can all be understood, in the present discussion, to implicate with different emphasis, measuring instruments as either a problem or solution. However, if, following the discussion in chapter 1, the distinction between mind and world are radically collapsed, the use of instrumentation is no longer validated by a need to access an authentic reality.

Chapter 3 will address the themes identified here in the context of the historical development of medical instrumentation, in particular with reference to the way in which is was incorporated into hospital treatment. The history of the development of medical instruments raises particular themes such as the role of the patient as subjective perceiver. As will be seen, these ideas add a further layer to the previous discussion of problems posed for scientific practices by the subjectivity of the scientist (physician).

Chapter 3. Objectivity, subjectivity and medicine

Chapter Three extends the discussion of objective measurement to the realm of the body, by considering the introduction of instrumentation into medicine. It examines the major movements in the critical literature that contribute to a methodology for understanding this history.

The chapter will develop the themes of subjectivity and objectivity as they relate to the practice of measurement and diagnosis. Medical instrumentation provides a useful focus for the discussion because the way it is talked about often represents a superficially simple view of the relationship between human actors, technology and reality, and at the same time incorporates a deterministic understanding of technological change whose objectivity is open to question. An uncritical attitude to the neutrality of medical instruments is exemplified in Lewis's (1920) statements (discussed in the previous chapter) regarding the electrocardiograph and described in Joyce's (2009) analysis of popular descriptions of MRI imaging technologies, both discussed in the previous chapter. In these formulations instruments are unproblematic, 'transparent' transducers and transcribers of the physical world; considered simply as machines, their relationship to that world appears deceptively straightforward.

This chapter describes an alternative approach to understanding the origins, applications and uses of medical instrumentation. Its makes use of histories of medical technology by scholars like S.J. Reiser – whose work provides a history of the role of technology in medicine (Reiser, 1978 ;1993) – but will depart from Reiser's critique of the negative influence of medical technologies. The chapter will use the example of thermometry to elucidate some of the more contemporary critical approaches to instrumentation. It will discuss how actor-network theory (ANT), a theoretical approach to understanding technological and cultural relations, and the emergence of technological and scientific entities, might influence how we consider the development of a medical instrument such as a thermometer; revealing the multiple causes and negotiated nature of its production. The chapter will then consider how contemporary scholarship unravels the multiple forces that bring an instrument into being, enabling it to become reified – or, what electronic engineers might call 'black-boxed' (Latour and Woolgar, 1979, p.242).

This chapter will introduce a range of approaches to understanding the meaning of body measuring instrumentation, as both scientific technique and as a way of representing the human body. Such approaches have developed as an alternative to – and a critique of – popular discourses regarding technology that tend to regard all technological medical advances as unquestionably positive. This trend leads to a deterministic view of medical equipment as a collection of self-defining objects, whose function cannot be interrogated or renegotiated without risking accusations of Ludditism. But it is reductive to assume that the apparently benign and fixed world of 'things' is innately objective; the values inherent in a technology's representation of the body need to be teased out, and the usefulness of that technology pragmatically assessed.

There is a good reason why this chapter looks so closely at medicine. Not only is there a highly developed scholarship of medical history, but physicians and other medical practitioners also find themselves in a problematic position as regards the relationship between technologies and subjectivity in their practice.

Medicine is both an art and a science; it blends the ethical, the scientific and the pragmatic. Medicine maintains a tension between the values that inform scientific practices – namely, objectivity, rationality and evidence – and the humanistic imperatives that stress the influence of factors such as lived experience, meaning and ethics. As Byron Good (1994) asserts, he is 'convinced that medical anthropology is one of the primary sites within anthropology where alternative responses to the confrontation between historicism and the natural sciences is being worked out' (p.24). That two potentially conflicting paradigms are present within the discourse of medical practice may well account for the number of disciplines preoccupied with the study of medicine, often referred to collectively as the 'medical humanities'.

A look at the histories of medical devices shows how physicians of the 18^{th}- and 19^{th} centuries not only adopted but also resisted novel medical technologies; the latter less evidence of the backwardness of early physicians than a demonstration of the often fraught range of imperatives and both 'ways of thinking' and 'uses of the senses' (Kuriyama, 1999, pp.12-3) present in medical practices of knowing the body.

Scholarly criticism of medical objectivity

As outlined in the previous chapter, the historical relationship between scientific epistemology and ontology is complex; this chapter will examine how the resulting debates and tensions have influenced the development of instrumentation. The opening section will illustrate how the epistemological concerns of science introduced in the previous chapter have impacted on the thinking and methods of physicians, as well as on how the practice of those physicians is understood by other disciplines. This discussion will make particular reference to the problematic relationship between subjectivity and diagnosis.

That subjectivity and objectivity have been formulated by Kantian philosophy as complementary-but-opposing ontological states has influenced the way some disciplines have sought to address contemporary medicine and hospital technologies. Consequently, there is a general sense of the pertinence of this philosophical discourse, which sees a disjunction between scientific accounts of the body and the sociological, psychological or anthropological accounts of a patient's (apparently incompatible) socio-subjective experience of illness. However – and while these debates rarely come down to comparing ontological status – while arguing that it is neglected, medical humanities scholars do not consider patient testimony to be of equal value to 'objective' medical data; just as it is rare that the physicians they observe actually treating patients consider psychological, social or experiential (for example, symbolic) factors to be either effective or medically relevant.

In discussions of technology in hospital settings, the problematic philosophical terminology of subjectivity vs. objectivity pervades the literature, particularly as seen in the scholarly work of nursing practitioners and physicians, such as James Lynch's (1999) sociological investigations in the Intensive Care Unit. Almerud et al. (2008) comment on the inability of theoreticians to not 'beat the proverbial dead horse'(p.55). While Lynch's work signalled a valuable contribution to a turn toward an understanding of the effects of negative emotion on cardiac health, in many cases this literature concludes by claiming an apparently mysterious ineffability is at work. For example, Lynch decides that 'something' is missing from technological science; it cannot give an account of the subjective factors that are so powerful in these settings. In his history of medical technologies in the hospital, S.J. Reiser similarly falls foul of the terminology. He criticizes physicians' increasing reliance on technology, and argues that this has led to a reduction in the amount and quality of their interaction with patients. 'Objective' medical measurement means that physicians no longer *need* to speak to their patients, and the patients' own experience of their symptoms ceases to be so relevant. Conversely, with the introduction of mechanical objectivity as both trope and method, medical practice has achieved an even greater distance from its own object – the actual body of the patient. Automatic measurement techniques and technologies – from graphing temperature readings (charted by nurses to later be consulted by doctors) to the electrocardiograph, CT and MRI – now enable physicians to carry out a consultation to a standard which meets professional norms over the telephone. While it is reasonable to argue that physicians' over-reliance on instrumentation is neglectful of their broader duty of care,[69] the argument that subjective or 'innate' knowledge is inherently superior to technical practice can only be made with oblique reference to the extra entities which have been attached to Kantian subjectivity. Byron Good's anthropology of medical rationality describes the difference between the 'ordering of reality' by physicians and the reality of the sufferer. In biomedicine (the branch of contemporary medicine informed by modern science);

> Disease is located in the body as a physical object of physiological state,

[69] Reiser also suggests that subjective ways of knowing are eclipsed by the introduction of technology into hospital practices. This is also suspect - later scholars, such as Anne Marie Mol (2008), and Daston and Galison (2007), suggest instead that a richer combination of methods of knowing are in use in contemporary medicine and science. Mol's anthropological studies of hospital practices suggest that different types of medical knowledge-gathering do not simply replace one another: for instance, patient testimony - information about day-to-day functioning, or how far they can walk without getting tired - might be assessed alongside more high-tech diagnostic information such as an angiogram (a form of x-ray) to build a larger clinical picture. Daston and Galison note that differing types of objectivity present overlapping and co-existing tendencies in thinking about scientific evidence, rather than distinct eras in which one method replaces another. For example, contemporary scientists refer to the epistemological values such as trained judgement and mechanical objectivity when considering the quality of the evidence they produce from a particular experiment. This mixture of approaches supports Mol's observations regarding clinical practice in medicine.

> and whatever the subjective state of individual minds of physicians and patients, medical knowledge consists of an objective representation of the diseased body (Good, 1994, p.117).

However, in Good's anthropological world-view, the medical aspect omits essential aspects of the body:

> The body is subject, the very grounds of subjectivity or experience in the world, and the body as 'physical object' cannot be neatly distinguished from 'states of consciousness' (p.117).

But this discourse is a thorny one. Not only is the term 'subjective' already value-laden in its scientific setting (patients' experience of symptoms can be said to be 'only subjective' or 'all in the mind'), there is also an unsettling power dynamic at play when one person designates what is and is not physically real in the body of another. Correspondingly, to many practitioners in the medical humanities the notion that subjective experience is inconsequential to medical practice is anathema. However, even Byron Good's advocation of a phenomenological aspect to the study of medical experience lacks a correlative instrumental and practical grounding; the impact of experience on healing or body state is not discussed, and experience is treated merely as epiphenomenon. While subjectivity is certainly still relevant (it can be argued that the human life lived in misery is not worth extending, regardless of the medical picture drawn of that physical body), it is – according to Good's model – extraneous to practitioners concerned with the 'real' healing of 'objective' disease. By this reckoning, while the real, subjective experience of illness is fundamentally and inextricably linked to its organic counterpart, its close relationship is one defined by difference – it is ineluctably present, but distinctly separate. The dualistic ontology is maintained; experience is not incorporated into the objective ontology of the human body, and remains cut off.

Reiser's work describes two stages in the history of medical diagnostics in which doubt of subjective testimony plays a part. Both are presented as origination stories in the development of contemporary medicine. The first is the progression of medical diagnostics away from patient interview and towards methods of physical examination, and often involving instrumental techniques such as urinalysis, percussion, pulse feeling and auscultation (listening to the interior sounds of the body). One story involves Lannaec's invention of the stethoscope, created from a rolled up tube of paper and enabling him to listen to the heartbeat of a female patient upon whose chest the mores of the time prevented Lannaec from placing his ear. Lannaec's stethoscope – like several other devices such as the ophthalmoscope, a magnifying glass for close examination of the eye – offered physicians broader methods of examining patients, though they remained comparable in effect to older, venerated practices such as pulse reading.

This early innovation is cast by Reiser – as well as scholars in fields such as health studies (Sampson, 1999, pp.3-21) – as one intended to avoid the subjective and unreliable account by a patient of their own symptoms. Rather than have to speak to a patient to elicit the precise nature of their problem, these new techniques of examination allowed the body to speak for itself. This concept of consulting the body directly can be traced throughout medical history, from ancient Chinese texts about physicians who would not allow their patients to speak until they had felt the patient's pulse, or '*mo*'[70] (Kuriyama, 1999).

The second stage in Reiser's history charts the introduction of an instrumentation that solved the problem of the physician's own subjectivity. For all the apparent necessity of scientific objectivity when establishing a reliable view of nature, the introduction of medical measuring instruments and automatic data-recording devices was by no means as inevitable a development as has been retrospectively suggested. Historians of medical technology writing in the late-19th and 20th century appear bemused by the ambivalence of physicians to the medical innovations of thermometry, respiration, and pulse counting (as distinct from pulse *feeling*, which has been the norm in most Western medicine, a variation of which continues to this day in the Chinese tradition). Silas Mitchell in his 1892 address to the Second Congress of American Physicians and Surgeons – of which he was president at the time –

[70] The *mo* is the quality measured in Chinese pulse measurement. While the practice looks similar to the contemporary western equivalent - a light pressure of the physician's fingertips on the patient's wrist - it is in fact very different: rather than count a beat, Chinese physicians feel for particular qualities of the *mo*, which is conceptualised as an energy flow throughout the body, rather than the changing movements of arterial blood. Kuriyama (1999) has written a fascinating comparative study of the historical development and major concepts of Chinese and Western medical practices, which includes a more in-depth description and consideration of the *mo*.

asked:

> Does it not seem incredible that of numberless physicians who sat by bedsides, thoughtful, with fingers laid upon that bounding artery, none should have had the idea of counting it? (Mitchell, 1892, p.17)

Mitchell then later goes on to say:

> How useful, how simple, it seemed to count the pulse and respiration, or to put a thermometer under the tongue, and yet it took in the one case a century, and in another far more, before the mass of the profession learned to profit by the wisdom of the few (Mitchell, 1892, p.24).

Matters were, of course, not so simple. The new historicist approach to mapping the development and adoption of new technologies, and the evidence offered by more critical historical accounts of medical technologies, such as Reiser's *Medicine and the Reign of Technology* (1978) tells the other side of this technologically determinist tale, offering counter arguments to Mitchell's rather condemning view that "error died hard" (Mitchell, 1892, p.23). Instead, examining the way in which new technologies were used, thought about, debated and developed by both technologists, physicians and the public, shows the complexity of outcomes of a novel technology, and in the case of measuring instruments, the dependence of the way in which the final phenomena measured by the device – in the following, body temperature, was at different points in its history open to different interpretations and manifestations.

Social Construction of Technology and Actor-Network Theory

The following discussion of thermometry will move beyond the technologically determinist and classical view of instrumentation, in which instruments are developed from iterative experiments, slowly improving in their function of interfacing with, and representing reality. In the last thirty years, developments across the humanities dealing with technology such as sociology, anthropology and philosophy, have developed alternative approaches to understanding the forces shaping the way in which technology develops. Before focussing further on the particular case of the thermometer, the primary aspects of some major currents in this scholarship will be described in brief – these being the Social Construction of Technology (SCOT), which considers new technologies to be the result of social factors rather than reflections of physical nature; and Actor-Network Theory (ANT), which analyses technologies in terms of networks of different actors.

Social construction as an approach to understanding technology emerged in the mid 1980s (Bijker et al., 1990), partly in response to the emerging approach of Sociology of Scientific Knowledge (SSK), proponents of which were concerned with establishing a relationship between scientific facts and the social and cultural circumstances of their conception. As Bijker et al. (1990) describe it, SSK takes as a 'central tenet' that; "in investigating the causes of beliefs, sociologists should be impartial to the truth or falsity of the beliefs, and that such beliefs should be explained symmetrically"(p.18). This 'symmetrical' treatment means that sociologists are required to seek elsewhere than in the scientifically established explanations for why certain theories, explanations and facts are chosen over one another.

> Within such a program all knowledge and all knowledge claims are to be treated as being socially constructed; that is, explanations for the genesis, acceptance, and rejection of knowledge claims are sought in the domain of the social world rather than the natural world (Bijker et al., 1990, p.18).

The theory of social constructionism has had a considerable influence on science and technology studies; its view of scientific and technological entities as products of social groups (and their actions) offers a more hopeful and flexible model of the relationships between human cultures, actors and desires.

As an approach, SCOT drew attention to the powerful influence that cultural understandings and interpretations of technology have in its development, influences which were previously often neglected by historians and theorists. However, as a strong program, SCOT also had its limitations. The main arguments propounded by the SCOT model amount only to a partial counter to the problem of an overly mechanistic view of technology. In particular the approach fails to deal with a continuing ontological division between the idealist and realist conceptions of technology, and by attempting to source the criteria for technological forms in the social, rather than the natural, it compounds the conceptual separation of physical and social reality.

In contemporary scholarship the influence of 'strong program' social constructionism has waned in favour of a more supple analysis of scientific products, one less open to the charge of being inherently idealist or unsustainably relativist. This is achieved by rejecting the assumed separation of a physical, material reality from cultural or social forces, suggesting alternative approaches and ontologies. Contemporary scholars are now as likely to describe science's relation to physical reality as a process of 'framing' rather than 'constructing', making clear the pre-existence of a world to be investigated, elucidated and manipulated. Critical approaches like Actor-network theory and posthumanism have emerged, which both pointedly reject that is it meaningful to make any distinction between social and material reality, and question the concept of materiality as it is modelled as prior to human knowledge. These movements can be broadly characterised as 'anti-essentialist'.

The posthumanist position, championed by thinkers such as Haraway (1991) and Pickering (1992), is one approach which aims to reconcile the tension between the material agency of the physical world and the social forces that have powerfully influenced the shape of new technologies by embracing an alternative ontological frameworks (such as the 'flat ontology' described in chapter One) which rejects traditional separations between orders of thing, such as that between human and machine, natural and social. In a posthumanist framework, it is non-sensical to argue for an either-or causality of technological form and change, instead the interdependence and complexity of the relationship between mixed entities are stressed.

ANT can be seen as both product and critique of SCOT literature. Bruno Latour, who coined the term 'Actor-Network Theory',[71] is an outspoken critic of sociology's tendency to reify 'the social' as a force. Latour (2007, p.68) claims this tendency lends the field a kind of confused dualism, tying it to theoretical objects that have no ontological significance but have simply come to stand for the network of forces and interests described as social (as opposed to, for example, 'natural'), while the depiction of these as such is an empty dichotomy. The influence of ANT on technology studies, and – as will be discussed later, medical anthropology – has led to more flexible accounts of technology where they are understood as physical practices or entities shaped by embedded in wider networks of meaning and action. As Latour has argued, the connections (what he calls 'alliances') between actors (people) and actants (things) are so ubiquitous they can be seen to materially *constitute* their objects. The term 'social', and the concept of 'social forces' has become extraneous, and technologies, rather than being a set of things or object, are better considered as a set of human *practices* in a constant processes of resisting, manipulating and creating objects and facts.

Latour has argued that ANT offers a method (rather than a theory) by

[71] Latour has since taken some pains to revisit, and attempt to clarify what is meant by the term, particularly stating that he is troubled by the meanings ANT has taken on since the introduction of the web, when the term 'network' has become less flexible and rhizomatic; indeed, other commentators on ant theory like Law and Mol have suggested that the term 'fluid' or 'train' might be more suitable in its place.

which social science can reconcile the local and global within its subject. Allowing it to address the disjunction between the two levels of its inquiry, the micro- (local, grounded interactions and observations) and macro-level (explanatory structures such as society, culture and norms – those forces responsible for the forms observed actions take).

> Ant is merely one of the many anti-essentialist movements that seems to characterize the end of the century. But is also, like ethnomethodology, simply a way for social scientists to access sites, a method and not a theory, a way to travel from one spot to the next, from one field site to the next, not an interpretation of what actors do simply glossed in a different more palatable and more universalist language (Latour, 1999, p.21).

Latour's description of ANT as a 'method' is supported by much of his early work, drawing heavily upon the use of case studies – such as the development of scientific facts (1979) technologies such as the Diesel engine (1987) and scientific and medical entities such as microbes (1993). However, Latour's work, taken as a body (and keeping more recent texts in mind) can be seen to constitute a particular philosophical position,[72] and this is reflected in the way in which philosophers are now responding to his work, in particular, Graham Harman's *Prince of Networks* (2010) describes Latour's work in terms of a philosophical project.

The influence of ANT and the anti-essentialism described by posthumanists on the following account of the development of thermometer

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[72] According to Harman's (2010) preface Latour is about to publish a book which positions him as a philosopher, at the time of writing, this text has been through a process of review by other scholars (Harman included) but the contents are not public.

technology can be seen in the way in which it questions the traditional and somewhat linear history of the development of the device, from 'crude' early versions, through a period of flux in which there were superstitious understandings of its meaning and possible application. Instead, the short account below ties together – and re-appropriates some aspects of the history that are discarded in retrospect. It also foregrounds the role that the device had in influencing the resulting production of temperature as a disease – fever – and the tension between the way in which temperature as a phenomena can be considered as a fundamental aspect of physical matter, a state which can be measured as a universal by instruments such as thermometers. In particular, this discussion is intended to raise the prospect of the necessity, and problem, of context within the activity of producing measurements. Whilst we might describe what a thermometer measures as the energy of particles of a particular space in the environment or piece of physical matter, when applied in medicine, the thermometer is linked to and precipitates certain types of action. Human body temperature is thought to be relatively stable at 98.6 degrees Fahrenheit, a measurement between 100.4 and 104 degrees Fahrenheit is considered to be a fever, temperatures above this are often considered to place patients, particularly children, at risk, and classify them in need of immediate medical attention. Taking a person's temperature sits within an understood pattern of possible actions and diagnostic criteria.[73]

[73] NHS Direct - Check your symptoms. Available at: http://www.nhsdirect.nhs.uk/checksymptoms [Accessed November 7, 2010] ; *Caring*

Thermometers, fevers, and temperature

The following section will use the example of the thermometer to emphasise certain dimensions central to the development of novel technologies that may be overlooked. David Nye, in *Technology Matters,* (2006) identifies stages of technological invention, innovation and diffusion. These stages do not necessarily follow a smooth pattern of conception (invention), design and improvement of a device so that it might be adopted and manufacture and then adoption of new technologies, for instance when the initial ignorance of potential users has been overcome, or affordable manufacturing processes are arrived at. Often it is necessary for users to innovate a use for and social meaning of a technology before a clear understanding of what it is becomes clear. This process has been well documented in new historicist studies of the development of many media technologies. Novel forms of media technology can be seen to be in a state of flux, open to innovation and experiment, and importantly, to definition by the social uses that are innovated around and through them (Gitelman, 2006). For example the early telephone was used to broadcast a whole range of media as entrepreneurs 'scrambled' to find uses for the new technology – amongst them live music concerts, faith healing, weather reports and emergency news

for Your Child's Fever - Department of Pediatrics. Available at: http://www.cpmc.org/advanced/pediatrics/patients/topics/fever.html [Accessed November 7, 2010].

(Fischer, 1994, p.66). As Punt (1995) explains, the emergence of the cinema as a recognisable media form was not a result of the right set of technologies becoming available, the mechanical and chemical apparatus necessary were available 50 years prior to the emergence of a recognisable cinema. In fact the ideas and understanding of what cinema was, and what it meant, that motivated early innovators in the field (Paul, the Lumières, Dickinson and Mèliés) were highly divergent (p.390).

The forces that shape medical instrumentation and other technologies – and designate the possible and most efficient configurations of an instrument – are not only industrial; as the following discussion will show, there is far more flexibility and contingency in the possible forms an instrument can take. By examining the history of the thermometer, and the some of the variety of factors that have shaped it, we are invited to consider the alternative forms the device might have taken had influences been balanced differently, or scientific and medical practices not come to adopt it in a particular way. While the thermometer would not qualify as an instrument by the terms of all the literature surveyed above (particularly in Latour's contemporary laboratory), an account of the thermometer's history and 'reification' as a device – including the establishment of practical protocols around it, and its use, within the larger apparatus of body-monitoring equipment – will illustrate the theories already laid out and enable them to be pragmatically assessed. This section of the thesis does not aim to provide a complete history, but to make clear that the tensions that accompany the production of devices are related to many different voices and values. The thermometer as we know it, as a 'textbook' instrument, is an embodiment as much of scientific and philosophical values as it is of a particular phenomena – temperature.

It is likely that readers of this thesis have used a thermometer of some kind to measure their body temperature, or been the subject of thermometric measurement. Thermometers are a medical measuring instrument commonly found in the modern western home, and the familiarity of the device makes it a telling case, demonstrating how something so quotidian and apparently straightforward actually exists in a state of constant flux and (re)negotiation. The history of these instruments (such as that suggested by Davis, 1981) is like that of many other technologies, often depicted as one of trial and error – successive improvements that eventually reveal the 'best' form. Certainly the thermometer is rarely interrogated in common use; we take for granted that it must be sensible, logical, and of the optimal form for the functions it performs – but this is a post-hoc rationalisation. Even a cursory look at the history of the thermometer will demonstrate that there are certain necessary requirements for a device of this kind to come into being - to be, in Bachelard's words, *reified*.

In recent years of course thermometers are often electronic, but as the electronic thermometer is designed analogously with the glass and mercury version, for the purposes of simplicity it will be this traditional kind discussed in the following. This comprises in its idealized form a hollow glass tube that is usually between 5 and 30 centimetres long, with a bulb at one end containing mercury. The other end is sealed and often straight, though sometimes better shaped to fit parts of the body other than the mouth such as the ear, underarm, or anus. Contained in the tube is an amount of liquid metal mercury that, depending on its temperature, expands in size, filling the tube to a greater or lesser extent. On the side of the tube there are regular, numerical markings. The mark and number to which the mercury aligns is calibrated to correspond to a particular temperature.

The construction of temperature as a universal

Thermometers (and thermoscopes, their non-metrical predecessors) have been built for a long time and in various ways, with different liquids or gasses expanding or contracting in response to temperature variation. Between 1593 and 1597 Galileo developed a crude open thermometer using glass bulbs set in a bath of water (Mitchell 1892, p10). Whilst he used the heat of his hands in order to test the device, Galileo appears to have not investigated the possible use of the thermometer in the investigation of disease (Reiser, 1978, p.110). In 1613 Sagredo announced in a letter to Galileo that he had improved Galileo's system by hermetically sealing and adding a scale to it (ibid). A multiplicity of methods for the production of temperature methods has existed since, thermometers have contained linseed oil, water, mercury, alcohol in various forms (p.112). During the enlightenment the question of a system of universal calibration for thermometers was raised, and a variety of alternatives proposed and debated, some more fanciful than others. With doubts cast on the reliability of the chemical behaviour of materials used in thermometers – in particular, mercury – the consistency and objectivity of the device has varied throughout its history, to eventually settle into the relatively simple form with which we are today familiar.

In its early form, the thermometer and barometer were the same, and so measured changes and temperature and pressure simultaneously. In 1644 Torricelli discovered the effects of air pressure allowed the thermometer and the barometer to be separated into two different instruments by the sealing of the glass tube (Castle, 1995, p.23). The barometer (or weatherglass as it was known) was developed by members of the Royal Society, particularly Robert Hooke and Robert Boyle (ibid) and improved throughout the second half of the seventeenth century, leading to the general adoption of mercury, and eventually uniform scales, although almost seventy different scales were reputedly in use during this period (p.24).

It is not only the case that the correct form and material of the thermometer and barometer have evolved over the last few centuries, Castle (1995) has noted that an evolution of the imagined components of their working took place as well, as evidenced by their metaphorical descriptions both by scientist and the way in which they appeared in literature and popular culture during the seventeenth century;

[...] with their curious, seemingly animate capacity to "feel" alterations in

> the atmosphere, weatherglasses, as they were known in the seventeenth century, lent themselves to metaphoric adaptation. In the hands of eighteenth-century wits, they became registers for measuring fanciful changes of all sorts–fluctuations in sexual desire, physical or emotional excitement, religious enthusiasm and so forth (Castle, 1995, p.22).

The early language of enlightenment scientists shows their interactions with early weatherglasses supported a more general experience of the device as having an unpredictable inner life, a temperamental and sensible nature that was somewhat mysterious. As Castle observes, in his *Micrographia* (1665), Hooke describes how to calibrate a sealed thermometer to zero degrees and create a device of 'tenderness'. Similarly Gustavus Parker's *Account of a Portable Barometer* (1710) is also cited, and Parker noted for his 'torrid' terminology, 'Terrine Emotions,' 'Effervescencies', 'Subterraneous or Submarine Eruptions,' 'Copious Effluvioums' and 'Protrusions of Exotick Force' (Parker, 1710, in Castle, 1995, p.25). Castle suggests that fluctuations of the weather glass and human emotions were further bound together by the unconscious impulse of early experimenters to tint the liquids be they mercury, 'spirit of wine' or linseed oil within their devices blood red, with 'lovely [...] cocheneel' (*sic*) (Hooke, 1635-1703, no page) or 'kermes, dragon's blood, or red wine spirits' (Castle, 1995, p. 26). These emotional instabilities and sensibilities were therefore not only present within the 'satiric' imagination of writers and comedians of the seventeenth century, but were part of the way in which early experimenters used and experienced the behavior of these instruments. The analogy of sexual excitement and loose morality chimed with the unpredictability of the device, which itself harbors the ability to 'feel'.

Later, the adoption of the device as a consumer technology also links to the emergence of a metaphor of a mercurial, changeable temperament where the thermometer becomes a focus for introspection and self-monitoring of the emotions. Castle identifies a number of Romantic poets who have referred to the technology in their work, citing both Rousseau and Keats, (p.34) and into the twentieth century in Freud and Flaubert (pp.38-40).

Medicine itself was not impervious to debates surrounding the possible application of thermometers. Which were not also limited to technicalities, such as the best way to build the device or to solve the problems posed by body temperature measurement, such as placement and protocols. More fundamental questions also came from those physicians who doubted the relevance and value of a measurement made by a device of this kind (Reiser, 1987, p.114). In contemporary eyes, the instrument that gives the most *objective* measurement is superior, with the numerical scale on a thermometer being the mark of such objectivity. However, in order for the measurement to be useful, it has been necessary to reify and narrow our understanding of the quality we have come to know as temperature - historically of central relevance to medical diagnosis and monitoring, temperature has been *a different thing* at different moments in history.

Despite the developments of the apparatus for the measurement of air temperature for use in meteorology, the general attitude of physicians towards the thermometer as a device for reading the body was dismissive. This might appear paradoxical considering that the relationship between increased body temperature, fever, and pathology has been significant to medical practice and has been recorded since antiquity – knowledge and traditions relating to the relationship between health and body temperature are pervasive in human medical cultures (Blatteis 2001, p.7). As crucial as it has always been, temperature-taking for diagnostic purposes – when it was the fashion – was always by hand, or reliant upon the accurate report of the patient. By this standard, the information provided by a thermometer was incredibly accurate – indeed, Robert Boyle criticised this new precision-thermometry as 'a work of needless curiosity' (Porter, 1999, p.344). However, what we might overlook, thermometry's one-dimensionality meant it was considered entirely inferior to the faculty of the physician's own senses; the thermometer could not hope to detect the "acrid, irritating quality of feverish heat" or other diagnostic indicators that could be gauged by hand (Reiser 1978, p.114). Physicians considered heat-measuring devices as doing only that, Reiser cites a French physician who stated that thermometers indicated:

> [...] not more than the degree of intensity of heat ; and these differences are the least important in practice; ... the doctor must apply himself, above all, to distinguishing in feverish heat qualities that may be perceived only by a highly practiced touch (ibid).

In order for a thermometer to in medicine effectively it must be applied in an appropriate setting; the data gathered from such an instrument does not specify the state of the patient's body as a whole - it calls for *interpretation.* However, the lingual *mis*interpretation apparently avoided by the introduction of numerical measurement is merely displaced onto the practices surrounding that instrument. And without a patient's medical history, the information provided by a device such as the thermometer is without context and rendered meaningless; without a set of known norms for the body – relating to age, sex, and medical history (or, in future, most likely genetic profile) – deviation from the norm is hard to assess. There must be a protocol for interpreting instrumental data.

It was not until the mid-19th century that physicians began to make large-scale studies correlating temperature with disease states using thermometric measurements plotted over time (Porter, 1999, p.344). An influential early pioneer was Carl Wunderlich, who published his *The Temperature in Diseases* in 1868, a book containing and commenting on data collected from almost 25,000 patients. This mass of information enabled Wunderlich to analyse the patterns of temperature change in 32 different diseases (p.345), allowing him to demonstrate the prognostic value of regularly-made and -plotted temperature readings, and to show that 'certain temperature oscillations were signs of particular maladies' (ibid). It was this graphing of a patient's temperature *over time* that constituted another technology – data logging and managing – and in combination with the simplicity of thermometer reading, led to the creation of a set of principles relating temperature variation to disease, and resulted in the increased use of anti-fever medications.[74]

Once the thermometer was established in a practical protocol for the production of knowledge (the diagnosis or prognosis and the consequent recommendation of a specific treatment of drug), various claims and counterclaims on its reliability as an instrument were made. Debates focused on its numerical scale, its construction materials, and the site and suitability of manufacture – all arguments thrashed out between interested parties and professional practitioners.

Medical devices of this kind are untidy, vulnerable to inconsistency. And it is the *users* of machines – technicians, for example – who in most cases provide the final context, determining a course of action on the basis of the machine's findings. Conversely, the 'mechanical objectivity' of a scan or graph must eventually be supplemented by the 'structural' knowledge of norms, past findings, medical histories – in other words, how the examined body fits into the patterns of the world.

Measurement, language and intersubjectivity

The adoption of techniques such as pulse counting came about partly as a response to a long history of knowledge-communication difficulties

[74] Porter notes that "Initially somewhat controversial, thermometry established itself, reinforcing the notion that specific, objective and preferably graphic data were fundamental to clinical practice. In certain respects, *pathology was being translated into recordings made by instruments*" (*my emphasis*)(Porter, 1999, p345).

between physicians. For example, training the next generation of practitioners to recognise intricate differences between types of pulse was problematic. Until at least the 18th century, pulse-taking was a process of reading certain *qualities* of pulse rather than simply counting heartbeats. Galen wrote at considerable length on the difference between types of pulse, and to the modern reader his terminology seems excessively fanciful and metaphorical: pulses long and short, worming, antcrawling, mouselike and gazelling. All this detail rested on the conviction that each pulse type could be felt by the carefully trained fingers of the physician and linked to a state in the body of the patient, leading to diagnosis (Kuriyama, 1999, p.61-70). It appears, however, that physicians lost patience with this hard-to-master and -communicate art. While the value of the pulse as a diagnostic tool went undisputed, Kuriyama (1999) offers several examples of physicians who criticised this overly subtle and unreliable mode of diagnosis. The history of the pulse can be considered a history of a 'nervousness about words' (p.70), and the move towards quantifying rather than qualifying the pulse was motivated by the perception that 'numbers suffer no semantic slack' (p.70).

Numbers offer an apparent solution to some of the problems posed by Bacon's idols; numerals are considered in western metaphysics to have an existence independent of the mind – a prior, platonic stability. While words might vary in their relation and correspondence to 'the outside world', or shift meaning between speaker and listener, numbers are universals. That each individual's interpretation of words is to some degree idiosyncratic precludes the reliable communication of knowledge, hindering teaching and scientific standardisation. An individual's expertise in interpreting the evidence of their senses no longer appears to count for as much by the 19th century as the ability of a group to reliably compare and communicate their observations.

Measurements taken using standardised instruments held a number of attractions for medical practitioners and scientists. Not only could such measurements be consulted by several practitioners simultaneously, enabling a discussion of the contents and main features of the findings, they could also be compared with one another over time, to show the development and changes of disease within the organism. Eventually, these measurements could be collated as tables and atlases detailing forms of normal or abnormal structures or events – these might then be used to provide authoritative consensus on group scientific knowledge, making it available to other researchers.

Somewhat later, towards the mid-19th century, scientists and physiologists such as Éttienne-Jules Marey began working with automatic recording devices, collecting and analysing records of movement and other physiological processes such as blood-flow or changes in blood pressure. Marey, who called his innovation 'the graphic method', was a trained medic whose interest in engineering led him to develop and improve a range of physiological instruments that could measure such things as pulse, respiration and gait in humans and animals. In particular, Marey adopted recording methods from the natural sciences, such as revolving cylinders and chronometers, which allowed his devices to generate very accurate graphical records of physiological activity. Marey's project aimed to 'put aside the senses of the doctor, rather than "extend" them in the fashion of the stethoscope or laryngoscope and instead create a form of "direct writing", the "graphic method"' (Dagognet, 1992, p.39).

Even before these forms of automatic recording were available, scientists put particular stock by the idea that objective measurements could be made if the correct form of disconnected attention were exercised. French physiologist Claude Bernard described the importance of objectivity, and the need for researchers to split scientific experimental duties between the work of the learned, hypothesising scientist (who sets up the experiment) and the uneducated observer, or instrument (who/which takes the readings objectively with 'passive senses', Daston, p.63).

It was commonly understood that a graphical record of bodily data such as a sphygmograph, was one of a range of methods enabling nature to write itself, providing un-interpreted documents for the scrutiny of scientists, much like imaging technologies like photography ('nature's pencil) and x-rays. In addition to this immunity from human intervention, images made by a machine detailed that which was not usually available to human perception, for example in the case of Marey's innovations in photography, because it moved too quickly.

Summary

During the 19th century there was an acceptance and increasing prevalence of instruments in the physician's arsenal. The stethoscope and opthalmoscope were two early sense-enhancing devices, and they allowed physicians to interrogate the patient's body directly rather than rely on the older method of interview, which needed the patient's compliance, veracity and articulacy to give the physician the information necessary to make a diagnosis. With the development of these instruments, physicians began to consider it possible to diagnose without patient consultation, the 'objective truth' of the body was considered to provide more accurate information than could be gathered by other means, such as patient report (Reiser, 1978).

While earlier instruments with their sense-extending capabilities had a number of useful attributes – enabling the living body to be 'autopsied' (Reiser, 1978) – they also picked up signs of disease (such as heart abnormalities or tuberculosis) prior to the onset of other symptoms, allowing medics to infer prognoses by tracking changes in the patient's state throughout the disease's course. These instruments also inspired trust and complicity in patients and their carers, as prognosis was now provided by a technological apparatus and expertise of reading and interpretation they lacked; physicians were lent an air of authority, adding 'credibility to their medical judgments' (Reiser, 1979, p.120).

Instruments of this type (such as the thermometer) naturally attracted criticism – charges that they created too much work in terms of their management, that they required regular application by trained individuals, and that the large amount of graphical data they produced was time consuming and difficult to interpret. Physicians were also critical of the distraction these devices caused, which worked to the detriment of other forms of consultation with diagnostic and clinical value (Reiser, 1979, p.120).

The notion of a subjectivity/objectivity split can be traced in the few critical works that address the history of medical practice and the philosophical implications of the role of instrumentation. However, we might consider this a pseudo-problem, generated in part by the complicated nature of the term *objectivity* (as discussed in chapter 2) and by the governing nature of the mind-body split, which in its different forms colours the way body and mind – and subject and object – are thought about.

Because of the way in which physicians have adopted and applied scientific methodologies in biomedical practice, the question of how experiencing subjects are dealt with within the conceptual structures of medicine have understandably become a point of concern for those working in disciplines (such as sociology and anthropology) that stress the humanistic aspects of medicine over the utilitarian and scientific. In some cases instruments have been implicated in these discussions, representing as they do a range of scientific principles that are often taken to link with objectivity, and therefore privilege the evidence constituted by, and maintenance of the material body, over the experiencing mind. However, if we, as the thesis does, reject the notion that instruments *a priori* can interface with the body only, at the expense or neglect of the experiencing subject, then there is no reason to suppose that instrumentation technologies are problematic because of their ontological status as physical objects. Instead, the question relates to how instrumental phenomena measured are understood to be more or less bodily and more or less related to the embodiment of the subject.

In order to make sense of this alternative view of instruments this chapter has discussed two related scholarly approaches to the analysis of emerging technologies, SCOT and ANT. Instruments like the thermometer can, if we examine their history in the right way, be seen to have not simply emerged in response to a pre-existing phenomena – that of heat – but to have taken a particular (and current but by no means fixed) form through a process of modification and dialogue. Not only the hardware which constitutes what we think of as a thermometer (which is a caricature of a device and likely vary depending on whether they are something you work with regularly, or remember from childhood) but also the protocols adopted by its users to make use of it, exist in variety of forms that they do because of the many different actors and actants which have an investment in the development of the technology. Within that process a further, and fundamental aspect of the practice of instrumental sensing thermometry has also been brought into a certain form of being, and modified by the interactions of the meanings of instruments and other ways of measuring, experiencing, and using that phenomena, that of temperature itself. This notion will be further developed in the next chapter, which will look at the relevant philosophical literature that examines instruments as productive of phenomena such as temperature, rather than simply revealing of it.

Chapter 4. Instrumentation and Phenomena

This chapter draws on Philosophy of Science, Philosophy of Technology and Science Studies literature to explore some key discussions of instrumentation relevant to the concerns of the thesis. Through a brief genealogy of the relevant philosophy of instrumentation, the chapter shows a number of ways in that philosophers have attempted to define instrumentation; as perceptual devices: that enhance, or produce an objective view of reality; by its productions: marks, inscriptions, technical images and phenomena; or with reference to its material, mechanical and logical embodiment of the relationships it manifests between representations (marks, inscriptions and technical images) and phenomena (reality).

While this review of approaches to describing instrumentation includes a number of useful ways in which instrumental technologies can be characterised, the main concern of the chapter is with a discussion of the wider context within which these understandings of instruments are interpreted; as producers of representations or links with reality. To this end, the discussion is primarily located around the discussion of scholars who have explored alternatives to the account of scientific instrumentation as a tool used to reveal, record, or mediate physical reality.

The result is that the chapter introduces an understanding of instrumentation that is not posited on a division between knower and reality, as shown to be a problem generated by Kantian philosophical concerns in the first two chapters of the thesis. Instead of instruments revealing a pre-existing reality, or contributing to the production of theories about that reality, in the following they are instead positioned as elements of practices that produce the real, an action that Karen Barad (2007) calls 'mattering'.

While retaining the methods of describing instrumentation as mark making, and linking to phenomena, this chapter will show that these descriptions can be repositioned within a broader understanding of instrumentation as part of wider practices that work to produce, and construct reality in particular ways. Scholars like Barad who have explored some of the particular implications of this way of thinking about measuring instruments, in the particular case of scientific measuring instrumentation and body imaging technologies, offer a way to reference wider discussions of technology which reject the Kantian metaphysics which separates instrumentation from the phenomena it produces.

The previous chapter presented an overview of the main movements in the critical literature that offer an insight into how factors influencing the development and form of technologies can be analysed. This history of the development of the thermometer, and the factors which shaped it, are evidence of the context dependent and constructed nature of measuring instruments. A question is posed by the understanding of technologies as determined by a mixture of factors; to what extent can factors which are not part of the physical world, for instance, those that are social, determine the final configuration of instrumental technologies, and the phenomena that they sense? This question is one that has been rejected by the scholarship that has followed the Sociology of Scientific Knowledge (SSK) and SCOT movements, and earlier ANT theory. As discussed in the previous chapter, Bruno Latour (1999; 2005) has singled out the particular idea of the social as highly problematic and critiqued the social sciences for its continued commitment to a dualistic framework. By rejecting an underlying dichotomy between two realms of nature and culture, the question above looses its potency as a potential problem. This chapter therefore serves to draw on the literature of instrumentation to show how these dualisms can be rejected in favour of an ontology in which the epistemological separation between knower and known, thing and representation, is no longer a given, but, as Barad argues, something produced by a particular instrumental configuration.

This chapter therefore extends the previous discussion of the thermometer with particular reference to the argument that it offers regarding the way in which the phenomenon of temperature has been produced by the particular form, conventions, and ideas surrounding the thermometer as an instrument. This is simply the idea that the ability to sense temperature, and in fact the existence of temperature as a category, is reliant on the existence of the apparatus that measures it. This chapter fleshes out that argument, using examples of similar claims made in the literature; that the phenomena which are usually considered to be independent properties of matter, such as temperature, that are rendered perceptible by instruments, are arrived at through processes of negotiation between physical, technical, discursive and social factors and are not pre-determined or pre-existing in 'Nature' as it would usually be understood.

To this end chapter 4 puts forward the claim that instrumental technologies produce phenomena through particular forms of interaction with the world. This claim is primarily defined by the way in which it recasts instrumental technologies as agents in the practice of *producing* or *framing* the world rather than, as they are understood in the classical sense, to make *what already exists* perceptible to human senses. It does this in order clarify the relationship between instrumentation and phenomena that is applied to the discussion of the human body in the later parts of the thesis.

As we saw in chapter 2, because of its development in, and a long association with scientific experiment, contemporary measuring instrumentation can be seen as an epistemological response to Francis Bacon's provocation: to construct devices and logical methods to aid and direct human beings in the acts of observation and record making. Until the last few decades, scholarship the Philosophy of Science and History of Science has tended (if at all) to depict instruments in a way that reflected this role as a solution to the epistemological problem of faulty or inadequate human perception. In this formulation, scientific instruments are considered only as technical devices invented to confirm scientific theories through experiment and demonstration, or devices through which the hidden aspects of the physical world might be accessed. In this view, instruments are tools to an end, and do not incorporate a value system or perceptual bias of their own.

With the invention of photography and other graphic methods of mark making, electrical registration and computerized data logging, scientific instruments have demonstrated increasing levels of sophistication in the mechanized process of transcribing nature directly onto a page or rendering it as an image, offering their users the appearance of mechanical objectivity. The discussion of the introduction of these aspects of instrumentation in medicine in Chapter 2 showed that the intention of gathering objective data using machines was a guiding concept for many users and inventors of instruments that measured the human body during the 19th century. However, the associations with a particular interpretation of the notion of objectivity - as referring to an authentic underlying reality - may preclude an understanding of the reciprocal interaction that instruments have with the world.

This interaction is in part revealed by the constructionist literature of SCOT and ANT, which reminds us that instrumental technologies are 'produced' by the interaction of forces that can be considered 'immaterial', with the more familiar problems of the inventor's laboratory and the entrepreneur's factory floor. What SCOT theory systematically reintroduced to the calculation and assessment of where technologies came from and the factors that determined them was the 'social' – whereby meaning and symbol might become factors that shaped technological form, both in its invention, manufacturing processes and diffusion, and interpretation by various constituencies of users.

However, this notion of the 'social' a force, or collection of forces that might have an influence on technological form is a concept later discarded as inherently problematic by proponents of Actor-Network Theory (Latour, 1999). For its critique, ANT retains the importance of the wide range of factors on the outcome of technological change, it attempts to maintain, a wide range of actors (human beings) alongside 'actants' (things) and variety of models from rhizomes to mangles[75] can and have been invoked to give a texture to this method of inclusive analysis.[76]

This method of analysis has been applied to numerous kinds of technology, transport; bicycles, cars, engines, As was shown in Chapter 3, this way of thinking about technology is particularly relevant to a discussion of instrumentation because of the reciprocal effect on the material reality that a partial determiner of the possible forms that instruments might take. In its process of eventual (and only ever temporary) reification, the thermometer becomes a device that frames a reality in a particular way, making it perceptible in a particular way. Thus the thermometer can be said to produce temperature.

[75] The 'mangle' is the model that Andrew Pickering (1995) uses to describe to give a sense of the complex 'dance of agency' that emerges in scientific practices, from the interplay of human, material and machinic agency. Here, in this "mangle of practice" the "contours of material and social agency are 'mangled' [...] emergently transformed and delinated in the dialectic of resistance and accommodation"(p.23).

[76] The extent to which 'actants' can be considered to have an influence that is an integral function of their structure or action upon the world, to what extent they might be thought to exhibit *agency* has been hotly debated, leading to some now infamous arguments between Callon and Latour (who support a notion of 'nonhuman actors') and Collins and Yearly who critiqued their position a regressing from a strong program SSK position to one which repositioned material reality as a determining factor in science, rather than social factors. As Pickering's overview of the 'Bath School' dispute picks out, Collins and Yearly failed to respond to the radical rejection of the 'social' and 'material' as two dichotomous realms by ANT theorists like Callon, Latour and Woolgar, who are no longer interested in the effects of one upon the other, but in the result of *practices* which *produce* the material (Pickering, 1992, p.21).

However, as this chapter will explore, this analysis can be extended to make a particular argument regarding what this production really means, an argument that is particularly relevant to how we might understand the interaction between instrumentation and the human body.

As Latour (1993) reminds us, contemporary theorists may be more inclined to think of the material as a concept that has its roots in modernity, and as Barad argues, following in part the feminist theories of Donna Haraway (1991) and Judith Butler (1993), the materiality of the body that can be produced as an effect of certain practices.[77] As the work surveyed in the following chapter suggests, instead of simply measuring and representing the forces found in nature, the use of instrumental measurement, particularly as part of experiments, can be seen an intervention on the world that actively engages in its description, as well influences its material configuration.

The literature of instrumentation

Instruments, apparatus, experiments and laboratories, have traditionally been considered peripheral to a philosophical understanding of the scientific project, which was to develop *theories* which could explain the inner workings of nature; technologies were a tool, or an epiphenomenon. In his *Representing and Intervening* (1983) Ian Hacking opens his chapter on experiment by observing that:

[77] Butler's (1993) work develops the concept of gender as *performative* in that it does not adhere to any pre-existing ontological category, but is produced through a range of practices and behaviours.

> Philosophers of science constantly discuss theories and representation of reality, but say almost nothing about experiment, technology, or the use of knowledge to alter the world (Hacking, 1983, p.149).

While the philosophy of Science as a field has existed for over 70 years, the philosophy of technology is a far younger discipline.[78] Since the late 1970's[79] a number of sub-disciplines focussing on the study of science, often branches of Sociology and Philosophy, have developed. These sub-disciplines responded to the arguments of philosophers like Hacking and Ihde that the physical embodiments of science should no longer be overlooked, and are in fact central to a clear understanding of how the sciences operate (Ihde, 1979, p.xi). Laboratory technology was no longer considered to be an outcome made possible by scientific knowledge, or tools devised only for the demonstration of theoretical proof. Understanding scientific technologies, the way they were used, and their meaning, became crucial to a critical understanding of science (particularly the physical sciences). In fields such as science studies and sociology, the scientific laboratory became the site for an anthropological study

[78] In 1991 Don Ihde observed that the field (Philosophy of Technology) was "at the end of its first decade as an organised subdiscipline" (Ihde 1991, p.iv).
[79] Prior to this period thinkers like Heidegger (2000) have drawn attention to the role of technology as a crucial phenomenon itself (rather than as a by-product of scientific knowledge). Heidegger's work has, and continues to have, a considerable influence on STS and philosophy of technology, particularly his *tool thesis*. This said, Heidegger's work and that of others in the STS phenomenology tradition such as Ihde, does not feature in any crucial in the argument maintained by this thesis, because of the emphasis of their work on an analysis of phenomenological understanding of scientific apparatus. While the phenomenological method has provided important ways to consider human interiority, it does not necessarily contribute to the alternative position with regards to an anti-representational model of instrumentation that the thesis aims to develop. This said, Don Ihde's specific philosophical contribution has influenced the research for this project (for example see Drayson, 2007).

of the processes by which knowledge of the laws of nature were arrived at.[80]

The new fields of Philosophy of Technology, Social Studies of Science and Science and Technology Studies[81], have tended to proceed from a philosophical background distinct from Philosophy of Science's heritage in analytic philosophy; as Ihde (1991) observes, Marxist, Phenomenological and Pragmatist traditions have all been far more influential in Philosophy of Technology (p.iv). This difference in background, often drawing on continental philosophical traditions rather that Anglo-American, has resulted in a different emphasis for philosophers of technology, and has given rise to the movements in Philosophy of Technology such as Social Construction of Technology (SCOT) and Actor Network Theory (ANT) that were discussed in Chapter 3. The reading of technology and the general approach to technological artefacts as the outcomes of multiple and complex processes is deeply embedded in the understanding of technology that is held by this thesis and informs its interdisciplinary approach to understanding instrumentation and its possible relation to the human body.

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80 The seminal book length study of this type was Latour and Woolgar's Laboratory Life (1979), which, even in its title, made the somewhat provocative suggestion that 'scientific fact' was a 'social construction', a position that the authors have since modified.

81 One influence on this change was T.H. Kuhn's *The Structure of Scientific Revolution*, in which Kuhn called into question the way in which science was considered to be an incremental process of discovery and correction. Kuhn's analysis suggested that scientific history could be divided into epochs, where different 'paradigms' as Kuhn described them, acted as lenses though which scientists interpreted the results of their studies. Inspired by the need to understand and explain the processes by which these ruptures were produced, a new generation of historians and sociologists were emboldened by an understanding that the underlying assumptions of a scientific practice, the current 'paradigm' might be open to questioning.

It is important to note the somewhat complex role of terminology in the following discussion. When talking about instruments, it is necessary to do so with reference to the wider context of their use, as shown in the previous chapter's discussion of the thermometer. There is a particular reason why treatments of instrumentation as an abstraction are not to be found in these examples; instruments are always part of wider practices. Within the references that have been chosen to inform this account of instrumentation, the major focus of each is rarely instrumentation itself. In Latour and Woolgar's (1979) work instruments are considered as actors within a sociological account of laboratory science. Hacking's (1993) analysis is based in the context of scientific experiment. In Vilém Flusser's *Towards a Philosophy of Photography* (2000) the focus of his writing is the camera 'apparatus'. What Flusser refers to as a 'deep analysis' of an instrument, cannot be maintained without concrete examples of the camera apparatus and its use to support his arguments.

In talking about the kind of output, products of instrumental or laboratory apparatuses, a number of terms are mobilized. Flusser (2000) uses the term 'technical image' (p.14) to refer to what Latour and Woolgar (1979; Latour, 1987) might describe as an 'inscription' (Latour and Woolgar, 1979, p.51) and Karen Barad (2007) as 'marks' (p.176). Each refers to the output of instrumentation or experimental apparatus, and to the causal relations that they are taken to have with phenomena, each encouraging the relationship of measuring apparatus to world to mark to be re-examined. These terminologies are not identical or entirely commensurable, but they each serve the thesis to provide a wider account, the details of which will be fixed in the following discussion.

Instruments as embodied theory

> The classical dichotomy between scientific knowledge (*episteme*) and technological knowledge (*techne*) was grounded in the ontological distinction between their objects: scientific knowledge is about "things" that exist of necessity, things that are universal, eternal, ungenerated and imperishable: technological knowledge is about things that have their origin in their maker, "things" that are variable, generated and perishable (Boon, 2009, p.78).

In the classical formulation, scientific reality and the technology that renders it knowable are fundamentally distinct. This apparent distinction leads to an epistemological question; how can technological devices, constructed and synthetic, generate true knowledge about the 'eternal' 'things' that are the objects of scientific knowledge? Instrumentation is constructed in order to make experiments that reveal underlying knowledge of the world, those 'things' that are 'eternal' and 'ungenerated'. By focusing on the problem of the veracity of the representation of reality provided by instruments, an assumption about reality itself slips in. This assumption is one that is inherent in classical physics, the notion that there is a fundamental difference between constructed scientific technologies, and the properties that they are intended to measure, and that these things can be separated.

Within this structure, the equipment of the laboratory maintains a role of a 'techne' that is inherently separate from the 'things' that it might be used to investigate. An early critic of this notion of instruments as conceptually separable from the natural world that they are intended to aid in the investigation of was Gaston Bachelard[82] (1984), whose formulation of the instrument as 'reified theory', tuned this traditional relation between theory and experiment on its head.

Gooday (2000, p.376) points out that a precursor to Bachelard's 'reified theory' is Pierre Duhem's description of instruments. Duhem, like Bachelard was a 'physicist-turned-philosopher' (ibid.). He argued that the description of physical instrumentation could be exhausted in a theoretical, 'abstract and schematic representation which mathematical reasoning takes over' from the 'concrete objects' from which instruments were composed. Duhem's reading of instrumentation *as* theory drew attention to the usually neglected role of instruments within scientific practices, however, it ignored the agency of instruments as independent physical objects; Duhem's account is idealist, instruments are placeholders for theoretical knowledge (p.377).

In distinction, Bachelard's similar claim was a reversal of Duhem's; ' [...] instruments are nothing but theories materialized. The phenomena they produce bear the stamp of theory throughout' (Bachelard, 1984, p.13) moved

[82] Bachelard's psychoanalysis of the scientific mind was a provocation in its re-examination of the minds of a group concerned with demonstration and maintenance of a supreme rationality. In performing an analysis he seemed to make the claim that something other than a distinct and mathematical rationality might be at work in the mind of a scientist, and in fact, might be of value to how we understand and produce scientific entities. Bachelard's ideas pre-date, and in fact, have a clear scholarly lineage to the social constructionist literature that we will introduce later in this chapter.

beyond the traditional dichotomizing of pure theory from physical objects, to produce a relation between these factors that was reciprocal. In his wider account of the tension between philosophical realism and rationalism in the scientific laboratory, Bachelard makes the practical work of scientists done with instruments themselves far more central to the formation of theory:

> Scientific observation… shows as it demonstrates…transcends the immediate… reconstructs first its own models and then reality. […] Now phenomena must be selected, filtered, purified, shaped by instruments; indeed, it may well be the instruments that produce the phenomenon in the first place (Bachelard, 1984, p.12).

In considering instruments as the embodiment of theory, and suggesting that their role might be better understood as that of *producers* of phenomena, Bachelard's philosophy laid the ground for the work that informs the following discussion. This notion of instruments shaping, filtering and selecting, can lead to the claim that idea that scientific technologies are part, and a significant part, of the construction of scientific entities, the idea that without the intervention of technologies, certain phenomena would not exist, or at least not be tangible in the way in which we recognise them.

Instruments as productive of phenomena

As Ian Hacking argues in *Representing and Intervening* (1983), certain phenomena produced in laboratory settings, whist physical, are (arguably) never produced anywhere else in the physical universe and did not exist prior to their creation by a particular arrangement of experimental apparatus. As an example Hacking describes the 'Hall effect', an electromagnetic phenomenon first *created* by Hall in 1879 as part of his explorations of electromagnetism (Hacking, 1983, pp.225-6). Another, more familiar example offered by Hacking is that of lasers, which whilst they are physical phenomena, are not naturally occurring, but now exist in ever increasing numbers. Lasers as devices, but also the phenomena produced by those devices, have been brought into being by the production of an apparatus (Hacking, 1983, pp.226-7).

As Hacking explains, the idea that Hall 'created' his effect seems paradoxical, and while; 'The apparatus was man-made. The inventions were created. But, we tend to feel, the phenomena revealed in the laboratory are part of God's handiwork, waiting to be discovered.' (Hacking 1983, p.225) He suggests that this confusion is due to the way in which we tend to think about scientific theories and phenomena, the result of a 'theory-dominated philosophy' (Hacking 1983, p.225). Theoretical 'laws of nature', are maintained as distinct from the technological constructions or productions of human activities, the idea that they might be somehow a result of our actions is counter-intuitive.

The discussion in this chapter will explore, following Hacking, an alternative to this dichotomy, the idea of phenomena as inseparable from the instrumental apparatus which creates them: '[...] the Hall effect does not exist outside of certain kinds of apparatus [...] The effect, at least in its pure state, can only be embodied by such devices.' (Hacking, 1983, p.226). This does not deny that the phenomena produced in laboratories like Hall's are real, or that they are part of the natural world. However, it draws attention to the necessary complexity of understanding the relationship between phenomena and the instruments discussed this thesis, where phenomena cannot be thought of as essentially independent or prior to instrumentation.

This chapter therefore aims to build upon the existing understanding of technologies as constructed, and analyses of the way in which technical descriptions of instrumental set-ups appear to offer a 'transduction' of 'nature' into legible inscriptions. It will also offer a critique of this view of instruments, based on its partial nature, in that it fails to sufficiently assess the role of instrumentation in the reconfiguration of the physical world. This reconfiguration or intervention has traditionally been the focal point of scientific experiment. The reason that this is important is that it makes a difference to how we consider instruments to interact with the world. This has an impact in later chapters, when the discussion turns to consider the concept of creativity in relation to instrumentation and bodies. Whilst not all practicing scientists, or users of instruments have a commitment to the notion of an underlying reality which remains physically unmodified by the interactions of instruments, there is a powerful distinction between the different epistemological standpoints offered by the various ways in which instrumentation, and more generally, experiments are considered.

The following section of this chapter develops some general themes relating to instrumentation from the literature; the relationship between theory and instruments; their physical embodiment; the concept of 'black boxing' and reification. It will then revisit the problem of the epistemological understanding of the way in which instruments operate as inscription devices or mark making devices and introduce the literature that describes how instruments produce marks that are related to phenomena from the work of Latour and Woolgar and Hacking. This notion of instrumental 'access to reality'- will be defined as the way in which an instrumental apparatus sets up a relation between physical reality and a marking (image or inscription). This is what Latour and Woolgar call 'inscription devices' (Latour and Woolgar, 1979, p.48).

This notion of 'access to reality' describes the classical scientific view that scientific instrumentation gives privileged renderings of natural phenomena. The aim of the following is to give some sense of the nature of this relation, the way it is produced and maintained, enforced socially as well as logically, and most importantly, allows the discussion to move past the classical view of instruments making phenomena, to a discussion of the way in which these set-ups can be argued to produce not just representations of a phenomenon – but the phenomenon itself.

The second section will conduct a survey of the work of a number of philosophers of science whose work provides an account of instrumentation as productive of phenomena rather than revealing of a given world or reality. It will perform a close reading and reflection upon the work of key scholars who have developed these ideas in their philosophical writings on science, Gaston Bachelard, Ian Hacking, Bruno Latour and Karen Barad.

Inscription devices

Latour and Woolgar adopted Bachelard's reversal of the traditional instrument-theory relationship in their ethnographic study of scientific laboratory practices, *Laboratory Life* (1979). The study is based on Latour's observations made during his anthropological field-work in an immunobiology research facility and develops an account of the machinery of the laboratory as *inscription devices.* Through his study of the scientists he arrives at the idea of 'inscription' as being the main activity of the laboratory. He tells the following story; in recording[83] the work of the scientists in the lab, he observes that the practices of the lab are particularly focused on and structured by writing;

> After several excursions into the bench space, it strikes our observer that its members are compulsive and almost manic writers [...] It seems that whenever technicians are not actually handling complicated pieces of apparatus, they are filling blank sheets with long lists of figures; when they are not writing on pieces of paper, they spend considerable time writing numbers on the sides of tubes, or penciling large numbers on the fur of rats... The result of this strange mania for inscription is the proliferation of files, documents and dictionaries (Latour and Woolgar 1979, p.48).

Latour does point out that there are machines in the laboratory that do

[83] Latour and Woolgar point out that (naturally) some members of the laboratory were angry with his description of the laboratory as an "inscription device", and "scientists as readers and writers engaged in a form of "literary activity" (Latour and Woolgar, Laboratory Life, 1979, p.53).

not write, such as those which 'transform matter between one state and another', grinders, shakers, and centrifuges. However the 'operation of apparatus which provides some kind of written output' has a 'particular significance'. (Latour and Woolgar 1979, p.51) These written outputs, *inscriptions,* are the laboratory's main product and a primary focus for the researchers working there. According to these observations, in *Science in Action* (1987) Latour's description of instruments is formulated as a description of inscription devices:

> [...] an instrument (or **inscription device**) [is] any set-up, no matter what its size, nature and cost, that provides a visual display of any sort in a scientific text. This definition is simple enough to let us follow scientists' moves. For instance an optical telescope is an instrument, but so is an array of several radio-telescopes even if its constituents are separated by thousands of kilometers. The guinea pig ileum assay is an instrument even if it is small and cheap compared to an array of radiotelescopes or the Stanford linear accelerator. The definition is not provided by the cost nor by the sophistication but only by this characteristic: the set-up provides an inscription that is used as the final layer in a scientific text. An instrument, in this definition, is not every set-up which ends with a little window that allows someone to take a reading. A thermometer, a watch, a Geiger counter, all provide readings but are not considered as instruments as long as these reading are not used as the final layer of technical papers [...] (Latour, 1987, p.68) (author's emphasis).

Latour's use of inscription as the main concept about which to orient his definition is useful[84] because of the focus maintained on the results of

[84] Latour's overemphasis on inscriptions as a device for explaining the whole of the laboratory, is somewhat limited. In his critique Hacking [1993] argues there is more going on when we use instrument, or in his account, when we do experiments, than inscription making. Latour and Woolgar themselves point out that not only does the account of laboratory work as 'literary' 'fail to distinguish [the scientists] from any other writers' (p.53) but also fails to make clear *what* they are writing *about.*

laboratory practices, rather than the material objects and machinery of the lab, or the particulars of their operation. The activities and intentions of those working in the laboratory are understood from a more pragmatic angle, in that numerous different methods, setups, and rationales might be combined within the laboratory practices in order to achieve the final goal of an inscription for publication. The reliance on inscription allows an account of instrumentation that avoids:

> [...] presuppositions about what the instrument is made of. It can be a piece of hardware like a telescope, bit it can also be made of softer material. A statistical institution that employs hundreds of pollsters, sociologists and computer scientists gather all sorts of data on the economy *is* an instrument if it yields inscriptions [...] the whole institution is used as *one* instrument[85] (Latour, 1987, p.68-69).

Latour's definition is useful to us in some ways, but not in others. The intent of his definition of inscription devices is a particular one, motivated by and fixed around the resolution of his major research question regarding the social shaping of scientific facts. Defining instruments in terms of what they produce is a useful tactic to counter mechanistic (instrumental) descriptions of their interacting parts. Throughout his writings, following Bachelard, Latour consistently refers to 'facts and machines' (1987) in the same breath, consistently collapsing any apparent disparity between these two orders of

85 He does also point out that whether or not a device counts as an instrument is historically contingent; "this definition of instrument is a relative one. It depends on time. Thermometers *were* instruments and very important ones in the eighteenth century, so were Geiger counters between the First and Second World Wars. These devices provided crucial resources in papers of the time. But now they are only parts of larger set-ups [...]" (Latour 1987, p.68-69).

thing which might otherwise be held in an apparent dichotomy.

Machines as windows on the world

In *Laboratory Life*, Latour and Woolgar (1979) also describe the lengthy process of 'transformations' needed to produce a biochemical assay. Beginning with the taking of samples by syringe from laboratory rats, to the arrangement and processing of these materials in tubes, and their mixing with other liquids and refrigeration, tubes of samples 'undergo a radical transformation', they are placed in a piece of apparatus which produces a 'sheet of figures' (p.49) and the material in the tubes are then disposed of. The data produced is then taken and input into computer system, alongside other data from similar 'assays' which then produces 'a data sheet [...] that was regarded as the important product of the operation. However, these sheets of figures are then merely filed alongside thousands of others like them in the library.' (p.50) This process continues when the technical staff use the data sheets to produce graphs using computer systems by technicians. The resulting graphs or charts, once 'neatly redrawn' might find their way into a paper published by the laboratory to stand as 'evidence' for the claims made within (p.50).

In this account, individual instruments are distributed amongst an apparatus, and contingent on a variety of factors for their success and configuration. An instrument might be composed of apparently non-material, but technical methodologies, or expand to inhabit the entirety of the laboratory, just so long as it maintains its functional purpose: to 'transform pieces of matter into written documents' (Latour, 1987, p.51). The graphed or tabular data produced by the laboratory is significantly linked – 'regarded as having a direct relation' (p.51) to real things or phenomena. As is clear from his account of the bioassay (and supported by many other studies of laboratory practices which have followed Latour and Woolgar's) this relation between 'pieces of matter' and 'written documents' is in some cases maintained through very hard work on the part of the scientists;

> The whole series of transformations, between the rats from which samples are initially extracted and the curve which finally appears in publication, involves an enormous quantity of sophisticated apparatus. By contrast with the expense and bulk of this apparatus, the end product is no more than a curve, a diagram, or a table of figures written on a frail sheet of paper. It is this document, however, which is scrutinised by participants for its 'significance' and which is used as 'evidence' in part of an argument of article. Thus, the main upshot of the prolonged series of transformations which, as will become clear, is a crucial resource in the production of a 'substance'. (Latour and Woolgar, 1979, p.51)

Latour and Woolgar's investigations regarding the workings of science in its production of facts, call into question the veracity of this link, the torturous nature of the assemblage in question. Their project brings to the attention of those outside of science the extra work that does into the production of evidence that is often removed before publication.[86] This 'sequence of

[86] Joseph Dumit (2004) has made similar observations in his studies of neuroimaging, where the production of final images for publication is a complex process open to many interpretive variations on the part of those working with instruments, even

transformations', each a verified back box within a larger assemblage of methods and instruments, is what links a 'substance' (in the immunoassay) or phenomenon, to an inscription. These observations might appear dismissive, critical of scientific practices, but in fact (as Latour observes repeatedly) there are many checks and balances built into the practices of science (such as peer review, reproducibility) that mitigate any claims that Latour and Woolgar's work is an attack on the value of scientific practices. What their work does is expose is the complexity, and most importantly, the arbitrary, quotidian, social and meaningful aspects of scientific practice that are usually obscured and hidden by the way in which 'facts' are presented for publication.

Vilém Flusser's (1984) analysis of the camera apparatus contains an excellent description that returns the discussion to the notion of mechanical objectivity introduced in Chapter 2:

> Their meaning seems to impress itself automatically on their surfaces, as in fingerprints where the meaning (the finger) is the cause and the image (the print) is the effect. It seems as if the world signified in technical images is their cause, and as if they themselves were in the last link in a causal chain connecting them without interruption to their meaning: the world reflects sunlight and other forms of light which are then captured on sensitive surfaces – thanks to optical, chemical and mechanical processes – and the result is a technical image. It this seems as if they exist on the same level of reality as their meaning. It seems that what

those highly developed and reified systems like MRI scanners, simultaneously, he observes that scientists are extremely conscious of the impact of the choices that they make on the possible reading of the documents they produce, and of the limitations of the studies that they undertake, as well as the sheer and huge effort and expense that is required to produce MRI studies, the awareness of this massive amount of work and considerable concessions required to generate a results in these kind of experiments, which are entirely obstructed by the final images which are seen by the public.

one is seeing when looking at technical images are not symbols in need of deciphering, but symptoms of the world they mean, and that we can see this meaning through them, however indirectly (Flusser, 1984, p.4).[87]

Flusser's cautionary statement that describes how the camera apparatus serves to distract us from the artifice involved in the production of images, appearing 'automatically' as 'symptoms of the world they mean'. This "apparent non-symbolic, 'objective' character" of what he refers to as 'technical images', which have the "observer looking at them as if they were not really images, but a kind of window on the world" (ibid).[88] This mechanical objectivity is how we come to understand instruments as mechanisms that allow 'meaning [...] to impress itself automatically'. Instrumental images, which in reality represent multiple levels of mediation – appear to dissolve, remaining unremarked upon, and concealing – in Latour's words; the complexity of their production in an 'other world just beneath the text [...] invisible as long as there is no controversy' (Latour 1987, p.69), "the use of certain pieces of apparatus makes it easy to get the impression that substances directly provide their own 'signatures'" (Latour and Woolgar 1979, p.51).

Hacking (1983) argues in favour of a realist interpretation of the

[87] For Flusser, apparatus are different to machines, in that they are not intended to change the world, to 'pluck' 'objects' from nature, but to produce symbolical information. The 'work' of a camera is to 'produce symbols' – Flusser points out that this account can be generalized to other apparatus – by the execution of a program. The camera 'produces symbolical surfaces according to some prescription contained within it.' Each variation of this 'symbolical' surface is 'a realization of one of the virtualities contained in that program' (Flusser 1984, p.26).
[88] An example of this discussed in Chapter 2, was that of the descriptions of body imaging technologies such as MRI, still often described by analogy to windows or photographs, or the ability to 'look inside' (Joyce, 2008).

perceptions made available through instruments. His position makes it possible to see that the theoretical descriptions of the working of instruments and their transformational descriptions have a more rhetorical than practical function. While he takes pains to establish that the appearance of 'seeing' through a microscope is in fact illusionary, and makes use of very different optical phenomena that usual sight, he claims that the causal relationships embodied by instrumental devices support a realist view of their representations. It is this causal relationship that validates a claim of 'seeing' with the microscope, as if it is a transparent tool:

> How far could one push the concept of seeing? Suppose I take an electronic paint brush and paint, on a television screen, an accurate picture (a) of a cell that I have previously studied, say, by using a digitized and reconstituted image (b). Even if I am only looking at a drawing of the cell. What is the difference? The important feature is that in (b) there is a direct interaction between a wave source, an object, and a series of physical events that end up in an image of the object… in case (b) we have a map of interactions between the specimen and the imaging radiation. If the map is a good one, the (b) is seeing with a microscope. (Hacking, 1983, p.207)

This 'map of interactions' that produces an image of a specimen is recognizable as a 'good one' in Hacking's account because the same structures or set of 'two- or three-dimensional' relationships are discernable in the both the map and in the specimen. (p.208) In terms of scientific realism, he maintains that admitting that an entity is observable with a microscope does not necessarily lead to a position of realism, while a 'commitment to realism about microscopy' is a requirement of admitting that we 'see' with the microscope.

Instruments that cross modalities, for example, mechanical movement to electrical signals, are understood as 'transducing' one form of energy into another, evoking a causal relation between the *real* phenomenon and its depiction or measurement. Some physiological sensing devices measure the 'correlates' of the phenomena of interest; for example, a respiration sensor measures the extension of the chest cavity by means of an elastic band fastened around the chest. The measurement known as respiration is inferred from this other measurement. The biofeedback clinical literature offers a caution regarding how these correlated readings are understood, the phenomena measured is not the *actual* respiration of the patient, only an instrumental reading which correlates with it. In the same way the expansion of mercury in a thermometer is a correlate with the local temperature of the body. While we are cautioned not to consider the instrumental measurement to be the same thing as the actual phenomenon it depicts, there is no question of the objective reality of the phenomenon, be it respiration or temperature. For some reason these things cannot be interfaced with directly, what is not suggested is that this might be because they are instrumental productions.

An onto-epistemology of instrumentation

The final section of this chapter will focus in more detail on Karen Barad's writing. Barad's work develops Neils Bohr's philosophy of instrumentation. Bohr's development of a theoretical account of the relationship between scientific experiment using instrumentation, meaning and physical nature was a response to problems he and his colleagues encountered in the interpretation of quantum phenomena in experimental setups. Barad's reading of Bohr offers a particularly useful way in which to consider instrumentation. It offers an alternative to the traditional models of instrumental interactions with reality from the position of 'knowing subject' and 'world' to that of devices situated within and reconfiguring of, reality.

This notion of instrumentation developed by Barad from the starting point of Bohr's work offers a rationalisation of the problem identified by Hacking above, where the difference between measurement or instrumental system is collapsed with the reality it is intended to represent. Barad describes Bohr's position thus:

> Bohr argues that classic physics seriously underestimates and undercounts the contribution that apparatuses make. Apparatuses are not mere instruments serving as a system of lenses that magnify and focus our attention on the object world, rather they are labourers that help constitute and are an integral part of the phenomena being investigated. Furthermore, apparatuses do not simply detect differences that are already in place; rather they contribute to the production and reconfiguring of difference [...] Accounting for apparatuses means attending to specific practices of differentiating and the marks on bodies they produce (Barad 2007, p.232).

Bohr's formulation of the relationship between instrumentation and phenomena as analysed by Barad offers a more fully developed alternative to the notion of instruments giving access to the real and producing a certain type of relation between knowing perceiver, world and instrument. Barad calls this approach one of onto–epistem–ology 'the study of practices of knowing in being' (Barad, 2003, p.829). The focus is not on the way in which instruments produce inscriptions, representations of the world, but of their performative dimensions, which produce and enact difference in the world.

Barad's work provides an alternative model of the instrument from that of an apparatus that produces representations, or translates the phenomena of the world into inscriptions that are legible for human understanding[89] (Barad, 2003). This is because this model leaves the phenomena of the world untouched – treating them as self sufficient and fixed – and reduces the possible agency of instruments and anyone involved in the practices of instrument making, experimentation, measurement and representation. Philosophers and historians of science have analysed the way in which scientific practices represent the realities that they investigate. The thesis follows the scholarship what builds on these observations, arguing that representations have a material impact on the body's expression. Thorough the insight instrumental practices can be understood to produce phenomena, the question is: How could this idea be exploited in creative practices that use instrumentation to measure (or evoke particular phenomena of) the human body?

[89] Barad (2003) offers an overview of the key responses in science studies to the understanding of science as a set of practices of representation rather than intervention.

In *Meeting the Universe Halfway* (2007) Barad develops a radical realist view, which incorporates an understanding of the way in which instrumental apparatus and produces phenomena, similar to the argument made by Hacking discussed at the very beginning of this chapter. Barad proposes a particular ontology of measurement, what she calls an *onto-epistemology*, based on her reading of Neils Bohr's 'philosophy-physics'.[90] Barad's work makes its own interpretation of Bohr's philosophy and offers an account of what she calls 'agential realism' which attempts to explain the reciprocal nature of the relationship between meaning, measurement and phenomenon in scientific experiment.

Indeterminacy

As Barad explains, Bohr's philosophical investigations were precipitated by a set of thought experiments relating to measurement in the quantum science of the 1950s. During this time there emerged a set of problems in the

[90] I treat Barad's work as a primary text because of the amount of work that she does in order to make a reading of Bohr's ideas, and her contribution to their development and the description of agential realism makes them her own work, as she comments 'my aim is not so much to provide a faithful representation of Bohr's philosophy-physics as to propose a consistent frame work for thinking about important epistemological and ontological issues. In addressing these issues, it would be just as dishonest to attribute the full development of this framework to Bohr as it would be to deny that my thinking about Bohr's philosophy-physics is everywhere present in my formulation'. (Barad, 2007, p.123). While Barad's philosophy of instrumentation is the result of a long tern study of Bohr's work. She notes the continuing controversy over the reading of his work. In particular there are certain ontological implications of Bohr's ideas that are never fully spelled out which are part of her main focus. In order to extend his ideas, Barad takes the position that Bohr is a realist, but that a redefinition of the term is required to bring it in line with Bohr's position (ibid).

interpretation of a number of thought experiments in quantum physics.[91] Bohr's work attempted to explain the anomalous behaviour of matter on the quantum level, most particularly the fact that certain measurements could not be applied to the same particle, meaning that certain attributes of particles could not be measured at the same time as others. This was the same problem in quantum measurement that had inspired Heisenberg's description of the 'uncertainty effect'. Heisenberg's resolution of the problem was epistemic, concluding that there was a limit to human knowledge of the attributes of a given particle, and that knowledge of two attributes of a given particle could not be known for reasons of a limit to human knowledge, hence the famous formulation, 'the uncertainty principle'.

As Barad explains, for Bohr the problem suggested a radically different interpretation, the concept of quantum indeterminacy. He postulated this concept as caused by the relationship between scientific measurement systems and the physical particles they interacted with. Bohr's notion of indeterminacy

[91] In one example of the 'Gedanken experiements' (thought experiments) which inspired Bohr's work, particles are sorted according to their 'spin' direction, depending on the 'axis' on which they are spinning, x, y or z. If there is a way to tell which particles were detected doing what, then the particles will continue to behave in the way in which they were measured. If there is no way of knowing what state the apparatus found them to be in, the particles maintain their quantum indeterminate settings, and are resorted differently the next time the experiment is performed, even though they have all passes through the exact same instrumental sorting system. Somehow, the mechanism of recording the state of a particle fixes it in that state. Various interpretations of this event have been suggested, that gravity (suggested by Penrose – according to Barad) or consciousness (Schrödinger thought that it was the conscious awareness of the taking of a certain state by particles that caused the collapse) are two examples. It was a great centre of debate in the early field of quantum physics, which eventually settled on the 'Copenhagen interpretation' that Bohr was particularly instrumental in working towards.

suggested instead that the measurable parameters of a given particle were not decided until the measurement apparatus caused them to manifest as one definite form. Nature itself, prior to the intervention of measurement was indeterminate. Bohr's understanding of this effect was that there was something intrinsic about measurement that causes it to be more than simply 'watching without touching'. For Bohr, an experiment cannot simply observe, because it categorises matter by causing it to adopt particular states. At a quantum level, that amounts to causing the indeterminacy of particles to collapse into 'mixtures of states' (p.346) (where all the different particles have taken on a specific state) rather than indeterminate states which are neither, both and all. Based on this principle, Bohr's work radically re-examines the epistemology of scientific measurement, which is based on a model of a knowing subject and external and separated universe of physical phenomena that can be studied while remaining unaffected.

Separating knower from phenomena

Bohr's concept of quantum indeterminacy suggests a radical reappraisal of the way in which measuring apparatus are thought about philosophically, one that goes far beyond our understanding of them as human constructions, or as the products of mixed ontology networks. In an earlier paper Barad (1999) argues that Realist and Social Constructionist positions both fail to reassess the way in which we understand the relation of instrument and world to be linked to a humanistic model of the knowing subject. She concludes with the suggestion that our bodily structure of brain behind eye has resulted in an intellectual heritage in which there is a tendency to, as Descartes did, separate inner knowing from separate outer realities, the thing that thinks and therefore 'is' is separated and contained.

Barad pushes her analysis further than Hacking's observation that experimental setups are constructed in order to evoke phenomena. She observes that:

> Bohr's insight concerning the intertwining of the conceptual and physical dimensions of measurement processes is central to his epistemological framework. The physical apparatus marks the conceptual subject-object distinction: the physical and conceptual apparatuses form a nondualistic whole. That is, descriptive concepts obtain their meaning by reference to a particular physical apparatus, which in turn marks the placement of a constructed cut between the object and the agencies of observation. For example, instruments with fixed parts are required to understand what we mean by the concept 'position'. However, any such apparatus necessarily excludes other concepts, such as 'momentum,' from having meaning during this set of measurements, since these other variables require an instrument with movable parts for their definition. Physical and conceptual constraints and exclusion are co-constitutive (Barad 2007 p.196).

Barad's analysis of Bohr's work suggests that by understanding experimental apparatuses as physical-conceptual in a non-dualistic sense, properties of objects are assigned to them through the process of measurement, not prior to it, the problem is resolved. He introduces a notion of what Barad calls 'quantum wholeness' (p.196) that denies a distinction between the 'object and agencies of observation'. By applying this notion of 'wholeness', Bohr's philosophy reconceptualises the 'phenomenon' as something that is produced by scientific experimental setups; rather than something that is waiting in the world to be discovered and examined.

> [...] the measured quantities in a given experiment are not values of properties that belong to an observation independent object, nor are they purely artifactual values created by the act of measurement (which would belie any sensible meaning of the word 'measurement') [...] measured properties refer to phenomena, remembering that phenomena are physical-conceptual (material-discursive) intra-actions whose unambigious account requires [as Bohr described it] 'a description of all relevant features of the experimental arrangement' (Barad, 2007, p.197).

Phenomena are the products of 'cuts' that produce subject/object distinctions in the world. Measurement is the practice of 'objectifying', making objects. Bohr's notion of objectivity is also useful; the 'marks' made by phenomena are what are objective in his account. Marks are not the product of 'inherent properties of independent objects' (p.197) being made visible. But Bohr points out that 'permanent marks – such as a spot on a photographic plate, caused by the impact of an electron – left on the bodies which define the experimental conditions' are 'objective' (Bohr, 1963, cited in Barad, 2007, p.197). As Barad points out, the result of this is that:

> [...] what is at issue is the very nature of causal relations: causal relations do not preexist but rather are intra-actively produced. What is a "cause" and what is an "effect" are intra-actively demarcated through the specific production of marks on bodies (Barad, p.236).

The reason that Bohr considers these marks objective relates to the fact that they can be read as an entirety, within the system that produced them. In addition to this, they are fixed and can be consulted in a collaborative and social context. An objective recording from an instrument or measurement is objective by its power to render and carry its meaning between social spaces (Barad, 2007, p.199).

Instead of accepting the chain of events model suggested by Latour, Barad gives us the opportunity to consider the working of instruments from a different position than the traditional scientific epistemological one of sceptically removed observer and privileged instrument. In Barad's formulation, experimental apparatus perform operations to produce/evoke meaningful difference.

Summary

This chapter has given an overview of scholarship that serves to clarify an understanding of instrumentation that provides a basis for the rest of the thesis. There are certain main aspects to the thesis' view of instruments. Latour and Woolgar's 'inscription devices' provides a notion of instrumentation that is not fixed by particular material systems, but instead by its function. At the same time it may also be comprised of larger setups or collaborations of instruments The chapter expanded on the discussion of mechanical objectivity begun in Chapter 2 by introducing Flusser and Latour and Woolgar's observations that instruments appear to offer a mechanism by which the world can make authentic marks. This observation does not depart from Latour and Woolgar's notion of inscription. As Latour observes in his discussion of laboratory science – the ostensible use of instruments is to 'transform pieces of matter into written documents' (Latour and Woolgar, 1987, p.51).

While Latour's suggestion is that inscriptions are the fundamental unit of instrumental production, this chapter went on to drawn attention to the way that instruments produce phenomena. The way in which they do this has been established by looking at Latour's descriptions of laboratory setups and Hacking's concept of a series of translations taking place in experimental setups. In addition and in development of these two perspectives, Barad's notion of instruments as performing 'cuts' between 'observer' and 'objects', making distinctions between entities that cannot be considered as fixed, enriches the discussion by suggesting that the relationship between instrument and reality can be radically readjusted, away from the classical position that informs a notion of mechanical objectivity, and links instruments to the real or authentic nature.

Barad's argument, which builds on Bohr's philosophy, is that there is no difference between knowing and intervening. In order to measure something, a process of reification must take place in which the entity being measured must be made to exhibit one state or another, a state which was previously indeterminate *ontologically,* not just epistemically. Chapter 5 will return to Barad's work to examine her commentary regarding the implications of these ideas on how we might think about the technology of ultrasound scanning in light of an idea of instruments as discursive-material objects; the a study of which can privilege or separate neither aspect, nor separate phenomena from device.

The next chapter will set the scene for a discussion of Barad's philosophy which poses a number of the questions for the thesis, in particular, what is the limit of a constructivist position with regards to the 'mattering' of discourse? How do these discourses regarding instrumentation impact on an understanding of the body, and how different bodies and different body phenomena may be legitimately framed and produced. It does this by exploring the medical humanities treatment of the production of human body states in medical practices, and seeks to show how the notion of a performative and productive dimension is key to some recent analysis of the way in which bodies and disease phenomena are produced and managed.

Interlude: Materialising meaning

As discussed in Chapter 4, instrumentation may be better considered as a technological form that produces phenomena. To materialise something is to make it tangible, to conjure it up from nothingness. When we use instruments, we do it in order to make visible things that we suppose to be already there. We measure attributes of matter that we suppose are underlying attributes of all matter, and all places in space, things that are pre-existing, waiting (given). This is the paradoxical nature of materialising that we find so difficult to deal with in our general thinking about using instruments, the fact that, as Barad points out, our measuring of things does not make them come into being in a strict sense, but it does make them 'matter' (p.137) in that;

> Matter is neither fixed and given nor the mere end result of different processes. Matter is produced and productive, generated and generative. Matter is agentive, not a fixed essence or property of things. Matter is differentiating, and which differences come to matter, matter in the iterative production of different differences. Changing patterns of difference are neither pure cause nor pure effect; [...] spacetime is an enactment of differentness, a way of making/marking here and now (Barad, 2007, p.137).

Barad's description of matter and mattering as a conflation of terminologies stresses that action of instrumental measurement is inherently meaningful, in a way that is immanent to what is measured, while the matter itself does, of course, matter, the act of measurement involves the 'intra-action' of the act of measuring as a discursive practice, this producing the phenomenon in question. Measurement is therefore a practice of imposing meaning upon the world, and it does this in a way that has a fundamental impact on the quality of the world. As we saw in Chapter 1, the human body, from a non-reductive materialist standpoint, is an embodied subject. Meaningful and symbolic behaviour are fundamental and pervasive aspects of the human body.

The radiologist stands in front of a light box and demonstrates how he would read an x-ray of a patient who is suspected of having lung cancer. Back half-turned to his audience, silhouetted against the clean white light, he is a perfect image of the visual trope, the 'doc-at-box' (Saunders, 2008, pp.303-4) recognizable from stock photography and hospital literature. The film that hangs before him is an x-ray of a woman's torso, just discernable by the shadowed contours of her breasts. Her name has been erased; this film now serves as an example for teaching and demonstration. First, showing us how to read, he tells us, a quick scan over with the eyes, to orient, check the position of the diaphragm, the size of the image. Is the body close enough to the film? Is it upright? He turns the film on its side, checking the ribs, turns it back, checking, fingertips moving over the film in a circular pattern, tapping out two semi-circles of points over the surface of the film, looking for spots over the white tissue of the lungs. He points out a few small patches of dark grey mottling, "there, there… another there", eyes scanning over, yes; the process of knowledge growing and connecting, the dots in the lungs leading to him looking back at the ribs for metastases; hunch hardening into certainty. "Yes," he tells us "something here and here". Through a process of trained looking, a diagnosis is arrived at. The final parts of the test are performed, routine checks, for other causes of concern, other risky looking organs, and masses, this a matter of form, since the clues would be there, a precaution against the obvious going un-noted.[92]

Even as a demonstration enacted using the film of a patient who has likely long ago died of her illness, there is gravity to this moment, to the radiologist's performance. Not just the demonstration of the impressive nature of the technological feat, the powerful 'vision'[93] of the machine that allows us to look inside the living body. A potential has been verified. The possible diagnosis has become true. The extent to which it was true was dependant on how much is currently invested in the method of diagnosis by x-ray, more tests might be ordered, a CT scan to plot further x-rays images across the plane of the body, an MRI, or biopsy – a microcosm of dissection, to identify the possible intentions and behaviour of cells.

Can we apply Barad's 'mattering' to our understanding of what happens in these tests? In what way is it possible to talk about the work of the radiologist, of the radiology suite as something that could 'materialise' a cancer? Surely it is pre-existing? If left unnoticed, untreated, a tumour would not fail to exist, but grow. But until the diagnosis is performed, the 'thing' that

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92 This text draws on an original description made by the author in notes from a workshop on Biomedical Imaging and Society at Warwick University in 2010.
93 Joyce 2009 (pp.49-55) describes a number of 'tropes' relating to medical imaging in her study of MRI scanning, in particular the notion of the scanner as imaging technology that affords that ability to look inside the body.

is inside that patient's body is not one or another; it is a potentiality. How does the change in this knowledge possibly effect the existence of the thing itself, of the patient's body? Could an artefact on one of these images make someone ill? There are cases of patients who have been killed by misdiagnosis, but that is part of the long tradition of iatrogenesis[94], not necessarily something more mysterious.

For all its potency as a moment, the radiologist's diagnostic performance is part of a wider story, a set of evidence gathered by the clinician. It is one component in the alliance that demands action, treatment – the alliance that finally produces the 'bad news'.[95] In Barad's words it is the performance of a particular 'agential cut'. The 'cut' performed might at first glance be represented as a literal one, one which produces torso stripped down to bones and hard tissues, it shows – or claims to show – what is and what is not 'there' what is present within a given location, it recreates the ability to open the body, to look for a lesion in the time honoured tradition of pathological anatomy

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[94] Iatrogenesis means roughly, *caused by doctors* – from the Latin. While the accidental killing of patients is well known in English history through some of the more lurid tales of British royalty being bled to death or poisoned by apparently well meaning physicians. However, contemporary medicine has its fair share of medically caused death and sickness, and is a particular problem amongst the elderly. Whether through misdiagnosis, drug addictions or 'adverse reactions', malpractice, and 'psychological factors', such as patient expectations about the outcome of their illness (Slade, 1997, p.507).

[95] At the same workshop Lui-Wen of Lancaster University brought up an interesting example of this from her sociological fieldwork in Korea with pregnant women and their perception of pre-natal screening using ultrasound scanning. One of her informants drew a lucky dip to symbolise her experience of ultrasound screening. Like Schrodinger's cat, until rendered visible, and then examined, prodded and probed, there is neither an unviable fetus or a tiny baby waving back, just a multiplicity of potentialities.

(Saunders, 2008; Joyce, 2009). But what it is cut from? In trimming down the object of study, the image stands in for the whole, the x-ray gives us an image of the material centre of the body, renders it transparent, but in order to make this legible, much else is removed, gases, liquids, head and legs, family, voice, all but a ghost of flesh. Following Barad's train of thought, what the radiologist sees certainly comes to 'matter'; it matters to a number of people. It matters also within a complex of different things, some of which may refer to the same illness, while others do not, as described in Mol's analysis of atherosclerosis. Within the regime of treatments, drugs, radiation therapy, surgery, pain relief, all of these things may be left undecided as to the type of disease and prognosis, only further, different tests might settle this, perhaps a biopsy, or a blood test. The cancer is manifested by the x-ray as a series of marks on film and the trained eyes of an expert who reads them, but it is also present as many other forms, as a pain, or fatigue, weight loss, a drug regime, the shapes of cells on a slide, nagging fear, visits from health visitors and nurses, or a substance in the blood. The cancer is defined as a sequence of measurable objects, the objects that might confirm it count differently for whoever is counting, and why and what they need to know and what they need to do. Even within the hospital, it assumes different states at different sites, different weight at different times. There is not a patient looking out, feeling ill, and a doctor looking in, seeing a disease, there are many people constructing their own frames for an amorphous thing which comes to stand for many activities, many meanings.

Chapter 5. Constructing Bodies

The previous chapter explored the relationship between instrumentation, experimental setups and phenomena in reference to philosophy that has considered the theme of instrumentation. This chapter makes use of examples of human body phenomena discussed in the medical humanities literature, to illustrate how human bodies can be understood as the products of medical practices. The theme of bodily production is explored with reference to disease, and the context of particular technologies, blood pressure measurement (as illustrated in a discussion of hypotension) and ultrasound scanning (with reference to foetal ultrasound).

The chapter explores the relationship between medical practices and body phenomena, particularly those related to disease through a number of examples from the literature of the medical humanities. These examples caution us against the idea that certain bodily phenomena can be considered as eternal, wholly products of scientific discovery, or cultural forces. Instead, it presents the work of a number of scholars who examine the way in which different disease and body states are produced by the interrelated actions of political, discursive, biological and cultural dimensions.

As we have already seen in the discussion of thermometer technologies in chapter 3, the production of a technical apparatus that allows physicians to make a particular measurement may encourage the conceptual development and reification of the particular type of illness, in the case of thermometry, fever. In this account of the emergence of a relatively static and robust form of instrument, the phenomena that it manifests, and the diagnostic potential are co-constituting. Common to the following examples, included because they extend this idea, is a rejection of the idea that medical knowledge, and instrumental monitoring and imaging practices enable representations of an authentic body. Instead, an alternative vocabulary is described, drawing on the work of Anne Marie Mol (2002); one that is more concerned with bodies and their phenomena as enacted, produced and 'multiplied'.

Embarking from a general overview of the scholarship that has taken as its object the historical and culturally relative nature of disease, the chapter will focus on some examples that illustrate the role taken by instrumental technologies in the production of bodily phenomena. By doing this it will show how certain theorists have conceptualised medical practices as active spaces in which instrumentation, meaning, and human action work to make manifest and comprehensible (as well as manage) the range of bodily phenomena that constitute disease.

One of these texts is Anne Marie Mol's (2002) anthropological study of the disease atherosclerosis. In Mol's ethnography the actions of physicians, nurses, patients and administrators as well as their techniques of management, treatment and examination, in Mol's term 'enact' the disease (2002, pp.32-36). Mol chooses to use the metaphor of 'enaction' rather than 'construction' or 'production' because these other terms give an impression that the activities of which she speaks create or generate the disease as an independent object. They reference the 'workshop' rather than the more appropriate 'theatre'. The disease 'does not stand by itself' (pp.31-2); it is, and is part of, the practices that frame its materiality and perform it, as she puts it, the way in which it is 'done'. In Mol's account, the disease is never separated from the practices that manifest it, the ways in which it is known, measured, acted upon.

Another example is offered by the historical account of the emergence of a new disease category, clinical hypotension, enabled by the development of blood pressure measurement technology (Postel-Vinay, 1996). A further example of medical instrumentation will link back to the previous chapters discussion of Karen Barad's philosophy of measurement by introducing her analysis of fetal ultrasonography.

Other examples in this chapter regard the changing nature of disease. Diseases slide in and out of existence. In *Lovers and Livers* (2005), Jacklyn Duffin uses two main examples to demonstrate the historically relative nature of disease, the first of these is lovesickness, the second, hepatitis C. Duffin's contrast between an historical (and to the modern reader psychological) 'illness' and a contemporary, in fact arguably 'new' disease, allows her reader to develop a broad concept of how diseases are produced by particular conditions.

As Duffin describes, the case of lovesickness, the malaise is at first metaphorical – found in the metaphorical palette of the poets of the ancient world. However, much later, in the 18th century, lovesickness became a medical problem, for which specific treatments are prescribed and diagnostic criteria are described, before a further transformation, where it becomes the concern of the new discipline of psychology. Hepatitis C is shown to be the product of a variety of political, and legal concerns as well as technical issues relating to diagnosis such as the problem of differentiating between hepatitis C and already defined categories of the virus, A and B.

Duffin is not alone in arguing that it is simplistic to think of diseases as things that are simply out there, waiting to be discovered. Bruno Latour's *Pasteurisation of France* (1993) deconstructs the famous myth of Louis Pasteur's discovery of the microbial agents of disease. Latour describes this history afresh, taking care that the microbes are considered as agents in their own discovery alongside the work of social health movements, medicine, and numerous other actors. All of these different collaborating forces and in Latour's terminology, 'alliances', (1987, p.126, 138) were what made the concept of microbes meaningful and worth acting upon. As Latour notes, the microbes were 'not much at first', (1993a, p.261) but through the assemblage of a network of different groups and objects that supported the understanding of their particular operation, form, constitution and meaning they were reified, and methods and instruments for their management were developed and supported.

Latour's account of the development of a science and medicine of disease causing microbes shows how it is possible to understand a network of determining factors as giving rise to a particular discourse or entity. Rather than claiming that an entity has been 'constructed' by a particular discourse, social context, or set of research – or, in contrast, assuming that the entity itself has been discovered because of the distinct form it takes, it is possible to consider these entities as emergent forms of sense making, but sense making that is not only constituted by conceptual structures provided by language, but also material practices. These practices, as similarly described by Mol's concept of *enaction* show that this process is temporal and active, and as will be shown in the next few chapters, easily incorporates an account of instrumentation.

Illness and disease

A particular duality has long been a feature of the philosophical scholarship around health and medicine, the distinction between illness and disease (Canguilhem, 1989, p.91). While the notion of illness as the subjective counterpart to disease, its organic, bodily counterpart might make it appear to be the less fixed of the two. The idea that a disease can be considered separately from the circumstance of a particular illness that it causes, and therefore have an appearance of an independent existence from the body in which it is found is what gives diseases the appearance of having a solid and inscrutable aspect. However, Duffin suggests that the way in which illness is experienced is far more abiding than the categories of disease that we think of as 'objective':

> In general, illnesses change slowly – the constancy of human suffering is a medical *longue durée.* The human organism has always suffered from pain, swelling, thirst, hunger, anorexia, sneezing, cough, trouble breathing, fainting, fever, sweating, nausea, vomiting, diarrhea,

> bleeding, loss of movement or sensation, and sudden death – and various combinations of them (Duffin, 2005, pp.5-6).

By invoking this difference between the constancy of illness and disease, Duffin seems to suggest that there is a more timeless set of human body states, those that are experienced subjectively by the patient, as *illness*. However, it might be argued that distinction is not so simple, many phenomena of illness we can readily imagine which would be experienced as negative or unpleasant in a medical context, might, outside of this negative and threatening context, loose much of their negative meaning. Loss of movement or sensation is something that has been sought after or experienced as a side effect by people using narcotics, but would be frightening if it appeared without explanation. The human organism does not necessarily *suffer* from these states: crucial to how they are experienced is the context, sometimes a *diagnosis* of the cause of that state and an awareness of what it means that influences how it is experienced and what its meaning is.

We might argue that to vomit is to vomit – but culturally and historically relative arguments like Duffin's bring evidence to light that this is half the story. The meaning of vomiting changes with time and with context; there are as many ways to vomit as there are to say "hello". While there are ways to stimulate vomiting, this does not mean that the human body is a mechanical device with a single 'vomit function'. Also, in the same way bleeding; its meaning is dependant on context, and might have highly different valence depending on circumstances, as it was used as a medical treatment for a considerable period of history (Porter, 1999).

Therefore it is worth mentioning that it is not just the case that more complex understandings of different diseases as discussed below change over time; concepts and experience of illness are also open to a recalibration by their meaning. As apparently prenoetic, conscious experience of bodily events, Duffin's symptoms are influenced by meanings that relate to them.

This discussion, and possible objections, can be unpacked by referring to a psychological figure, Joseph Jastrow's duck-rabbit 'illusion'.[96] The duck-rabbit 'illusion', still used in psychological testing today as a 'reversible' or 'ambiguous figure' (Long & Toppino, 2004, p. 748), was originally used by Jastrow in order to illustrate the way in which the mind can switch attention between two interpretations of an image. In the context of the current discussion of bodily experience, it offers an analogy for the changing phenomenal experience of bodily symptoms. What ambiguous figures demonstrate is the interaction between 'sensory and cortical processes' in the perception of forms (ibid): showing that prior knowledge of a form is not phenomenally separable from the act of looking. The reading of the image is shaped within the act. It is impressive that there is an image at all; the duck and the rabbit exist through collaboration between the marks on a page, and in the mind of the viewer.

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[96] This figure is best known for its adoption from Jastrow by Ludwig Wittgenstein in *Philosophical Investigations*. Jastrow had originally discovered the image as an amusing cartoon in a German newspaper (Kihlstrom, J.F., 2010). The duck-rabbit and similar devices, such as the necker cube, wife/mother-in-law and vase/faces are all still a feature of contemporary psychological research. Long & Toppino (2004) provide a survey of the broad range of uses that these kind of ambiguous figures are put to – and provide a deeper analysis of the sometimes competing claims for what they mean.

Similarly, the meaning of a symptom might transform its experiential characteristics.

Duffin suggests that it is possible to make a distinction between the aspects of illness as they are experienced bodily, and disease, as a historically contingent set of structures for understanding and treating illness. However, this is shown to be complicated by an understanding of embodied perception, as it is demonstrated by the duck/rabbit illusion, as well as studies of medical experience from medical anthropology which show that the experience of illness as a something that is, at its core, modified by and interrelated with cultural values, meaning, knowledge and prognosis.[97] Instrumental devices that measure the state of the body enter into this interplay between knowledge, meaning and perception and provide structures for understanding experiencing bodies.

Lovesickness

Diseases can shift between organic and psychological status, and are dependent on the availability of possible treatment, demand for treatment, and other negotiations for their status as medical problems. Duffin (2005) charts the history of lovesickness. From ancient medicine to the present day,

[97] Exemplary of this argument, and already discussed in the thesis are the work of Byron Good (1994) and Daniel Moerman (2002) on the relationship of knowledge and meaning to the experience, and in Moerman's work, the outcome, of disease. The possible integration of instruments into the phenomenal landscape of illness is speculated on further with reference to findings in health psychology in Drayson (2009).

physicians concerned with understanding lovesickness and dealing with it were often concerned with the establishment of criteria for what was or was not a bodily disease. By the majority, lovesickness was held to be the result of a problem of the soul, rather than an organic disease of the body, but one that was still accompanied by bodily symptoms, such as a racing pulse. However, as Duffin shows, lovesickness also was able at one point in history to become a diagnosable and problematic disease state.

Lovesickness appeared as a popular metaphor in antiquity, from ancient Egyptian love poems, to the poetry of the Greeks and in Biblical stories. (Duffin, 2005, pp.43-5) However, it was considered not to be the preserve of physicians. In the 2nd century AD, Galen was concerned to make clear that the pulse might be altered by strong emotion as well as by other physical imbalances in the body - such as the excess of 'black bile' that was responsible for melancholy. Galen argued that feeling the pulse made possible the diagnosis of the *false disease* of lovesickness.

Later, in the 4th century AD, Oribasius of Pargamum (326-403) designated love as a particular and organic disease, with diagnostic criteria and treatments (Duffin, 2005, p.49). Love was, for Oribasius, unlike his predecessors, no longer a metaphor for an emotional state that might interfere with the diagnosis of 'real' diseases (ibid). Later physicians considered love to be a cause of mental illnesses such as melancholy and mania (p.50). By 1724, medical writers like Sauvages (1706-67) were writing medical theses on the 'diseases of love', of which there were a growing number, lovesickness, what he called 'amorous melancholy', and other related mental disorders such as 'nymphomania' and 'satyriasis' (p.60). Duffin notes that, during the 18th century, influential physicians like William Cullen (1712-90) and Carolus Linnaeus (1707-78) identified erotomania as a class of melancholy. However, the dangers of love to the body were not forgotten; Napoleon's personal physician described the circumstances where erotic love strikes at the heart of a lover in a 'paroxysm of passion', others likened the effects of love that of 'malignant fever' (p.60).

Duffin identifies the period of the 16th to the 19th centuries as one in which the concerns with isolating anatomical 'seats' for the source of various diseases within the body, rather than 'identifying diseases by their symptoms' eventually led to lovesickness and its related maladies, of which there were an increasing number, to be redefined as psychiatric illnesses. There was a need to identify an observable organic change that related to lovesickness in order for it to be considered as a medical condition. Maladies that could not be resolved to specific sites or legions in the body became the territory of psychiatrists (Duffin, 2005, p.60).

The effect of a concern with anatomical identification was that lovesickness became once more a malady of the mind rather than body, equated with a number of psychological categories of perversity. Abnormal forms of infatuation are now thought to be forms of mental illness; in the present day the numerous psychological disorders can be considered as related to lovesickness as an illness (p.61). During the 20th century, many forms of sexual behaviour remained which were identified as illnesses, one example is that of homosexuality, which historians have mapped as making a long transformation from its identification as sin, to crime, to illness (Duffin, 2006, p. 62; Hansen, 1992, p.107).

Duffin (2006) refers to Bert Hansen's (1992) historiography of the 'discovery' of homosexuality by the medical profession in the 19th century. Hansen's argument extends past the idea that a pre-existing homosexuality was 'medicalised' or 'morbidified' (Hansen, 1992, p.107). Instead Hansen suggests that homosexuality itself was not discovered, but came about through an interaction between new urbanised living arrangements, social formations and new medical ideas and disciplines, such as neurology (p.110). In addition to patients seeking advice about urges and behaviours with which they were uncomfortable, physicians were encouraged to develop diagnostic criteria and treatment methodologies.

Hansen argues that homosexuality, as understood in the modern context as an attribute of a person, was not discovered, but that prior to this period, along with many other forms of socially 'abnormal' behaviour, such as stealing, was an act, at times considered dirty, sinful or criminal, but not a state of mind, predisposition, or type of person. As he observes; 'People's thoughts today commonly proceed, for example, from the observation of a theft to the recognition of a thief, from a crime to a criminal, and from a homosexual act to a homosexual' (p.107), but this way of thinking about people as inherently composed of their own acts and having certain predispositions is, as Hansen reminds us, a modern one. In the period of history that his essay maps, partly through collaborations between patients and their physicians (p.122), 'sexuality' comes to 'stand for something other than a person's sexual behaviour' (p. 109) and instead became related to proclivities and urges, cultures, identity and subjectivity, and ultimately, to a 'fundamental aspect of being' (p.121). Hansen cites evidence from physicians' notes of the time, which describe in detail the process of description and re-description through which a diagnostic category of 'the homosexual' emerged.[98] Interactions of these types can be the interactions that contribute to the process of disease 'framing', not just as a form of identification of a pre-existing entity, but the way in which through a range of factors and processes, it gains shape.

However, both lovesickness and homosexuality can be argued to be behavioural, psychologically based phenomena, and in a sense, self-reinforcing. As this thesis is primarily concerned with understanding how this argument might extend into the realm of the physiologically, and therefore instrumentally verifiable. To this end the following discussions will extend to Duffin's second historical case study, hepatitis C, as well as the other examples; Clinical Hypotension, its relationship to blood pressure measurement and ultrasound imaging, and the assigning of gender specific pronouns to fetuses within the medical context

[98] Hansen also sets this process within the wider historical context of new forms of medical specialisation, particularly neurology, and increasing urbanisation, which made possible the formation of new social groups and sub-cultures in way previously unavailable. (Hansen, 1992, pp. 105-6).

Hepatitis C

Duffin (2005) also develops an account of the emergence of the virus hepatitis C. Since ancient times a well-developed descriptive criterion for inflammatory liver diseases, 'hepatitis', has been in use (p.87). Through the establishment of a range of diagnostic methods 'hepatitis was teased out of a tangled morass of liver ailments [and] with the advent of autopsy, microscopy, cell theory, and biochemistry' (p.88) the boundaries of the disease were drawn. The different forms of transmission that forms of hepatitis can take, such as infectious hepatitis A, compared with hepatitis B, which is transmitted by serum – bodily fluids, only added to the confusion about how best to understand the etiology of the disease (pp.89-90).

One of the reasons that it became necessary to develop a criteria for hepatitis C was the increasing demand for blood transfusions needed to carry out new forms of surgery and methods by which screening of blood could be carried out were in greater demand (p.92). Even with the development of screening methods for serum infectious hepatitis B, a percentage of patients were still developing 'post-transfusion' hepatitis (p. 96), meaning that there was another, unknown virus which was being passed on silently by blood donors that was causing 'unexplained chronic liver diseases' (p.104). The ensuing search for hepatitis-C took 15 years, during which time it was referred to as 'hepatitis non-A non-B' (p.97).

Duffin's account draws attention to a recurring feature of medical testing. One result of the ability to screen possible blood donors for viruses was that a 'whole host of symptomless people would be classed as dangerously ill' (ibid). The need to detect the disease-causing agent prior to the development of symptoms was not considered necessary until the demand for clean blood increased. Patients and surgeons demanded that blood products be available, even when their possibly iatrogenic properties were well known, the short-term benefits of using blood and blood products were a powerful motivation to continue taking these risks. However, the result was increasing pressure on hospitals from litigation brought by the victims of disease spread by transfusion, which had come under increased scrutiny as it had become associated with the transmission of AIDS via blood transfusion (p.102).

The knowledge of the cause (some forms of hepatitis are more usually associated with transmission by blood transfusion; others by sex), the treatment and the prognosis were crucial in the long process of development of criteria for different forms of the virus. An awareness of the choices that had to be made through this process of negotiation which arrive at these criteria show us that they were not foregone conclusions, in a similar fashion to the animal or plant kingdom; the difference between different forms of the virus, between closely related forms of similar viruses, could be decided and influenced by a range of factors. To decide the most useful and pragmatic way in which to identify and deal with variants of disease, a lot of time and work and if not arbitrary, then contingent decisions in order to construct that disease as a particular detectable entity are required.

It might appear that a question emerges from Duffin and Latour's descriptions of the emergence of these phenomena, regarding whether entities such as 'hepatitis C' existed before their diagnostic criteria were established. How can real things, material, independent phenomena such as hepatitis C be constructed? Is a comparison between that and something so medically trivial and antiquated as lovesickness valid? By introducing us to the many contentious debates relating to hepatitis C and the circumstances by which it emerged as a distinct disease, Duffin makes it clear that, like temperature and lovesickness, hepatitis C is a condition identified within a particular milieu and a particular set of practices. She does this by showing the history of the illness, which through a long process of negotiations, was defined in distinction to the other forms of the hepatitis virus. Central to this activity was the availability of diagnostic criteria and instrumental apparatus that made possible the identification of different types of the virus using laboratory techniques, which made it possible to test treatment forms on different variants.

Instruments and technique in the production of disease

The notion of medical construction in the medical humanities literature has its history in the work of scholars who were interested in the workings of what we might call medical perception. Early works that dealt with these issues in philosophy were Michel Foucault's *Birth of the Clinic* (2003) and Canguilhem's *On the Normal and the Pathological* (1989). Both raise questions about medical epistemology and the conceptual problems and methods that have guided it. Ideas such as Foucault's 'clinical gaze', and Canguilhem's discussion about how notions of health and normality are established, both reference the decreasing role of the patient's subjective testimony in medical assessment – which Reiser imports into the argument of his *Medicine and the Reign of Technology* (1978) (as discussed in chapter 3). Instruments are implicated in the developing medical approaches mapped in these histories, and in the move away from illnesses to diseases, from experience and subjective testimony to observations and measurable facts.

The *Birth of the Clinic* (Foucault, 2003) charts the history of the emergence of clinical medicine in 19th century France in order to explore the development of medical perception. In it, Foucault talks not about the patient as medicine's object, but states that the new clinical medicine makes the patient, *as a subject,* the object of a scientific enquiry. In the new clinic, the patient is observed, catalogued and rationalised, all the parts of his case are gathered together, allowing 'the patient's "bed" to become a field of scientific investigation and discourse' (2003, pp. xvi-xvii). In Foucault's description, clinical medicine is not reductive in its use of instrumental measurement, rather than the blind cataloguing of figures and weights, he describes a more complex form of rationality, which

> [...] plunges into the marvellous density of perception, offering the grain of things as the first face of truth, with their colours, their spots, their hardness, their adherence. The breadth of the experiment seems to be identified with the domain of the careful gaze, and of an empirical

> vigilance receptive only to the evidence of visible contents (Foucault, 2003, p. xiv).

In particular, Foucault stresses the relationship between the practices of 'pathological anatomy' (2003, p. 2) the making of anatomical atlases from dissections, and the mapping of visible signs of disease in the interiors of corpses with those observed in the previously living patient's body. In the new clinic, the space of disease is localised to the space of the body.

He also offers another insight, when he discusses the evocation of the patient's symptoms, in particular the use of percussion (tapping the chest with fingers or a small hammer-like device and listening for changes in sound caused by variations in density, which modify the resonant properties of the chest) to find out the degree to which the chest is filled with liquid (p.119). According to Foucault, the method by which this could be done, and the rationale between the perceived differences in sounds and the state of the interior of the body were known. However he states that the technique was ignored by 'clinical medicine at the end of the eighteenth century' because it 'made a sign appear artificially where there had been no symptom, and solicited a response when the disease itself did not speak: a clinic as expectant in its reading as in its therapeutics' (pp.199-200). This questioning was 'prompted' later by 'pathological anatomy' in which the 'idea of a technical artifice capable of surprising a lesion becomes once again a scientifically based idea' (p. 200). The reason for this was the growing awareness that causes of death could be linked back to earlier, instrumentally detectable, states of the body. This concept is one that is central to the use of instrumentation in contemporary medicine. Charles Rosenberg (in Rose, 2007) has referred to the way in which technologies enter into the 'boundaries of disease' (p. 83) in this way as a form of 'technocreep' where 'diagnostic tools elicit signs that are taken as evidence of pathologies that were previously invisible' – generating what Rosenberg terms 'protodiseases' (p. 84).

The emergence of clinical hypotension again fulfils the promise of the development of a medicine that uses instruments for early detection. The diagnostic practices of hypotensive medicine start work on the body before discomfort is felt, they intervene medically in order to prevent. Like hepatitis C, hypotension is asymptomatic, the product of Foucault's 'expectant' clinic (2003, p.199). When its symptoms are found, treatments, and health enhancing behaviours are prescribed in order to prevent the disease emerging.

As Postel-Vinay's (1996) history informs us, hypotension was discovered because of the increase in the practice of taking blood pressure, it is itself not a disease in the traditional sense of the term, because it is not something that is suffered from. This move toward prevention however was not entirely motivated by humanitarian efforts, particularly in the case of the development of hypertension, an argument regarding its history and the relationship between the opportunities seen in the development of certain instruments, and the insurance industry, created the specific diagnostic category of hypotension. In the insurance industry, good forecasting results in financial gain, and protection for the insurer, against unforeseen risks (Postel-Vinay, 1996). Concurrently, the pool of investment against future difficulty, the insurance premiums paid by subscribers, could be easily turned toward the end of assessing the risk more and more accurately, and supporting the further development of scientific techniques that could do that. It is this relationship between large populations, statistical prediction and the provision of medical treatment through the insurance industry that has contributed to the development of statistical medicine and epidemiology (ibid).

Technological testing sidesteps the sufferer in the detection of disease, invoking a disparity with the Hippocratic oath, which describes the importance of alleviating suffering. An argument can be made in support of preventative medicine, but the ability to accurately predict the outcome of interventions (or lack of intervention) upon the body, and the possible development of disease are problematic. There are ethical considerations that are raised by these interventions. Both for patients on an individual scale, in the case of hypotension, but also with regards to larger populations, with technologies that detect contagious disease. One example that shows the discord between individual interests and preventative medicine is the debate about widespread voluntary HIV testing and treatment. Questions regarding the possible applications of advance testing of the possible benefits of a utilitarian approach to therapy show the complexity of the effects of developing and using these types of technologies.[99] Other diagnostic methods have also presented

[99] Recent debates about AIDs prevention strategies that might involve the

problematic aspects and become open to public debate, such as breast and cervical cancer screening.[100] All of these diagnostic practices carry possible benefits as well as dangers. In particular the way in which embodied experience is modified for the patient, as the interpretation of bodily feelings as possible symptoms are related to possible illnesses, the risk of unnecessary or ultimately damaging treatments is another, as well as the tension between the interests of the wider population and the individual.

Instrumentation producing bodies in hospital

Anne Marie Mol (2002) has made an ethnographic study that explores

prescription of drugs to those infected with HIV but not symptomatic reveal a tension between ethical concerns and epidemiological motives. Granich et al. (2009) have estimated that widespread testing and the prescription of antiviral drugs to carriers could dramatically lower the spread of the virus, as antiretroviral drug therapy (ART) can almost completely remove the risk of transmission. However, as they note, there is a deeper ethical problem with the prescription of drugs to individuals who would not benefit on an individual basis from the provision of anti-viral drugs until later, when their symptoms appear. One tactic could be to change the definition of disease symptoms, so that a lower rate of CD4+ cell count would be the standard at which it is beneficial to provide treatment with ART. This may become possible – researchers have been conducting a study that currently suggests that pre-symptomatic and earlier treatment with ART can prevent heart and kidney disease that seems to be caused by the previously unnoticed effects of the virus during its 'silent' phase within the body (Garnett & Baggaley, 2009). However, as Granich et al. note there is an inherent conflict of interest between individuals and society as a whole, between individualism and utilitarianism in the move towards widespread testing and early start drug treatments which carry the risk of 'over-testing, over-treatment, side-effects, resistance, and potentially reduced autonomy of the individual in their choices of care' as well as 'increased danger of stigma and coercion' for certain populations where these measures where treatment was resisted.

100 Singleton (1998) has published an fascinating laboratory ethnography that delves into the experiences of workers whose job it is to examine test samples during cervical screening and the insecurity and ambiguity that faces those engaged with the examination of cell samples, and the way in which hospital and lab culture work together to maintain a level of critical engagement with the technological testing apparatus that allows this ambiguity to remain a functional part of the diagnostic process.

how hospital practices, with different levels of consistency, maintain disease objects. This makes a useful example of how instrumental clinical practices might be understood as giving form to those objects in an ontological rather than epistemological sense. As Mol follows the disease atherosclerosis[101] through the different departments of her research site, 'Hospital Z', her account is concerned with the 'enaction' of the disease as an object by the various practitioners, such as nurses, physicians, radiographers, pathologists and patients whom she encounters. Because her focus on the activities that render the disease perceptible, Mol describes her ethnography as a 'praxiography'. Her account explicitly includes technology and bodies as they relate in practices of production and revealing, she stresses that hers is an ontological claim regarding the material reality immanent and necessary to these practices, a reality that is produced and shaped by these acts. Her account is concerned with practices and pragmatics.

As we might expect, Mol's text details a number of instrumental and other forms of measurement – such as interview – used in Hospital Z by her informants, patients, nurses, surgeons, pathologists, and technician, to gather information that might aid the diagnosis and management of atherosclerosis which she finds spread throughout the hospital. This leads to a particular concern for her work; to understand how the range of knowledge types about

[101] Atherosclerosis is form of arterial disease that involves the loss of 'lumen' (which gives arterial walls their flexibility) in the blood vessels causing loss of blood to the extremities (Mol, 2002, p. 54) The condition is sometimes referred to as 'hardening of the arteries' and can cause severe leg pain, preventing patients from walking more than short distances. Mol's description stresses the flexibility and shifting definitions of the disease between different sites of the hospital.

patient's bodies gathered by the instruments and practices that she finds are made commensurable with one another in a way that makes medical interventions possible.

As Mol observes, in the sociology of medicine, the principle, which is often applied to understanding the apprehension of the 'objects' of medicine, is to assume that practices which make those diseases and bodies perceptible are organised around a single disease object, a 'lesion' in the body of the patient. Diseases are either understood as lesion based, organic, and caused by particular entities, or systemic, relating to a disorder of a particular system of the body. The disease, as constructed by these practices, as a lesion within the body, is the underlying cause and focus of the multiplicity of techniques that are mobilised to detect, categorise, measure and manage these entities.

A major contribution of Mol's 'praxiography' (p. 31) is that it leads her to reject this account of the lesion as a singular entity below the skin, viewed from the multiple positions of different interested parties, a 'crowd of silent faces' (p. 12) assembled around it, looking in upon a singular object. Instead, Mol finds that in the case of atherosclerosis, the practices that enact it do not all point in to one underlying thing, but to a disease that is a 'multiplicity':

> The manyfoldedness of objects enacted does imply their fragmentation, although atherosclerosis in the hospital comes in different versions these somehow hang together, a single patient tends to be supplied if not with a single disease then with a single treatment decision, clinical findings, pressure measurements, social enquiries, duplex outcomes, and angiographic images, are all brought together in the patients file, together they support the conclusion to treat

> invasively, or not to do so. This then is what I would like the term multiple to convey, that there is manyfoldedness but not pluralism, in the hospital the body singular is multiple many. The drawing together of the diversity of objects that go by a single name involves various modes of co-ordination (Mol, 2002, p. 84).

Mol describes how, in Hospital Z, these multiple observations, all operating under the same name, are brought into line with one another as a cogent reality. The atherosclerosis that Mol describes is sometimes part of the patient's body, at others an element of day-to-day life, sometimes a slice of material on a slide taken from an amputated limb (p.54). It is not even a 'body multiple' that Mol seems to describe, but a multiplicity of disease framings, the patient's body itself does not appear to require a framing that would maintain it. What Mol points out is that the disease of 'atherosclerosis' changes form depending on the way in which it is evoked or experienced. Sometimes it is a function, or loss of it, sometimes it is a feeling; other times it is a piece of matter. While these differing aspects could be simply seen as the same entity viewed from different points of view, Mol suggests that the different 'enactments' or 'performances' of the disease produce multiple parallel but often very different disease phenomena which require considerable work in order for them to be brought into line and considered to as the results of a single cause. The praxiographic nature of her study demands that an ontologically specific adherence to actual phenomena and situations prevents the creation of generalisations of the disease, the 'praxiographic "is" not universal, it is local. It requires a special specification. In this ontological genre, a sentence that tells what atherosclerosis is, is to be supplemented with another that shows *where* this is the case' (author's emphasis) (p.54).

Mol's study signals something particular for the thesis' account of instrumentation, the question regarding this multiplicity of disease practices might be 'Where do the instruments begin?' When we look for instruments in Mol's account we find that technologies are not explicitly mentioned as a category of activity. Also, instrumental activities go far beyond physical devices, like machines and sensors, and describe data gathering techniques, charts, graphs, correlations, logical inferences and relationships between patient states, prognosis, treatment, the elements of a particular form of knowledge making, and a system for structuring, implementing, specifying and recording practices themselves. Instruments are spread throughout Hospital Z, as part of the practices and protocols that are used to fix different forms of disease in different places, to produce it as different entities at different sites.

Ultrasound and constructing subjectivities

One further example of an instrumental sensing apparatus, this time in the science studies literature, is ultrasound imaging. Drawing on the literature from the medical humanities and feminist scholarship, Barad explores her concept of 'mattering' previously referred to in Chapter 4 using the example of ultrasound, an 'apparatus of bodily production' (2007, p. 212). In her account of ultrasound scanning, the apparatus and the discursive structures that surround the practice of using it, work together to make objects and life forms visible in very particular ways. Barad reminds us that the things that are revealed by the scanner may mean very different things, and can be treated in very different ways:

> [...] in spite of ultrasonography's origins in sonar technology developed in World War 1, ultrasonography is not an idealized surveillance technology, a merely physical instrument that provides a view of a fetus as it exists independently of observational apparatuses. Rather, ultrasound technology designates specific material-discursive practices, constraining and enabling what is seen and produced in accordance with its iteratively intra-active technoscientific, medical, economic, political, biological, and cultural development as an ever-changing phenomenon [...] (Barad, 2007, pp.211-2).

As Barad observes, the meaning and effect of fetal ultrasound technology vary hugely depending on context and circumstances. In China, the sexing of fetuses as female using ultrasound results in, around 60 percent of the time, abortion or killing at birth. These acts of identification and termination are 'economic practices' necessitated by political and financial imperatives (p.194). In Western societies, where there is no explicit governmental control on population, the terminologies used to refer to fetuses are still varied according to their treatment and expectations regarding their future. Barad introduces Monica Casper's work on experimental fetal surgery, a domain where the fetus is constructed as 'a potential person with human qualities' (p.215). She refers to Casper's observation that foetal patients are 'routinely referred to as "the kid," "the baby," and "he"' (ibid). These 'human' terms which reinforce the sense of 'personhood' attributed to the fetus are supported by the use of ultrasound technology which make it possible to sex the fetus, but also to make portrait style images and real time videos at high resolution (ibid). The use of the scanner to produce visual images rather than (for example) sonifications, serve to further encourage the production of pre-natal 'portraits'.

Barad points out, that these kinds of images contribute to a situation in which the fetus takes the role of patient; the mother's body becomes the environment for the fetus's treatment:

> [...] technological improvements in foetal imaging, particularly material concerns such as increased resolution, magnification, and real-time images, encourage the patient and the practitioner to focus exclusively on the fetus, whose moving image fills the entire screen. Such material rearrangements both facilitate and are in part conditioned by political discourses insisting on the autonomy and subjectivity of the fetus. This has been accompanied by the objectification of the pregnant woman and the exclusion of her subjectivity. Material-discursive constraints and exclusions are inseparable– a fact we cannot afford to ignore (Barad, 2007, pp.211-2).

This is not to conclude that the effect of the instrument is so clearly calculated to give a sense of the fetus as person, or even potential person, but to observe the way in which instruments can come to support certain discursive structures and choices over others. The existing concern to look for evidence of the sex of the may be social, cultural or even medical imperatives. However, they all inform the way in which the technology is used, for example, the move towards 3D ultrasound scanning can be seen as less directed by diagnostic potential, and more for its popularity with patients in maternity units. The ultrasound scanner collaborates with ideas and institutions to perform its meaning on the patient's body(ies). As Barad describes it, the fetus is produced and maintained as an entity with specific properties by the intra-actions of various material-discursive practices:

> [...] the fetus is not a preexisting object of investigation with inherent properties. Rather, the fetus is a *phenomenon* that is constituted and reconstituted out of historically and culturally specific iterative intra-actions of material-discursive apparatuses of bodily production. The fetus as a phenomenon 'includes' the apparatuses or phenomena out of which it is constituted: in particular, it includes the pregnant woman (her uterus, placenta, amniotic fluid, hormones, blood supply, nutrients, emotions, etc., as well as her 'surroundings' and her intra-actions with/in them) and much more. The object of investigation is constructed through the enactment of particular cuts and not others [...] It is not a given that the object is a self-contained, free-floating body located inside a technomaternal environment; rather, this identification is the result of particular historically and culturally specific intra-actions of material-discursive apparatuses (Barad, 2007, p.217).

As Barad points out, the results of understanding the effects of technologies such as ultrasound through agential realism as material-discursive practices rather than practices of representation, is that it 'makes clear the need for an ethics of responsibility and accountability not only for what we know, how we know, and what we do but, in part, for what exists' (p.243).

Summary

This chapter has discussed literature from the medical humanities and science studies literature that offers examples of the way in which the human body is reframed by differing explanations of disease phenomena, made apparent through a variety and mixture of human and technological practices. Discussions of the formation of the disease categories of hepatitis C, lovesickness and hypotension demonstrate how diseases exist within a space between bodies and technologies.

As these histories also show, the space and form of diseases within the context and cause of body or mind may wax and wane with the differing notions of what and how body and mind are constituted in differing historical settings. The variations in how lovesickness was considered are testament to the fact that there is no fixity to how these things might be considered, how they relate to one another. Hypotension and hepatitis both demonstrate that there are a range of imperatives and technologies that shape the appearance and framing of diseases.

Mol's example of atherosclerosis in Hospital Z demonstrates the multiplicity of practices that materialise disease phenomena. If one is to understand the phenomena that are made apparent by instruments and practices as anything more complex than sets of numerical measures, then instruments must be understood, as they exist as integral parts of systems incorporating multiplicities of meanings and variance. Finally, Barad's commentary on foetal ultrasound offers a reading of relationships between bodies and instrumental practices, stressing the interrelated nature of settings, bodies and apparatus which gives rise to 'phenomena' such as the fetus.

Chapter 6. The Controlled Trial and the Imagination

The following section describes the early history of the controlled trial, a form of instrumental testing used to assess the efficacy (usefulness) of new medicines and sometimes to prove the value of traditional ones. This example is useful as it demonstrates how instrumental logic can serve to delineate the effects of the imagination, separating them from bodily phenomena that can be understood to have biological causes.

The controlled trial is familiar from the earlier parts of the thesis because of its relation to the 'meaning effect' described by Moerman (2002). Here it is discussed in more detail in its incarnation as part of the 'placebo response' as manifested by controlled testing used in clinical trials (most often used to assess medical treatments). What the discussion of controlled testing shows is the way in which the instrumental construction of the controlled trial does is produce the placebo effect as an anomaly, and denies a causal relationship between meaning and biology, one which is repaired by the arguments discussed in this thesis. The controlled test is a useful example in this discussion as it shows a way in which the logical inferences of testing situations and apparatus creates a managed body from which the active and biological effects of knowledge, experience and meaning may be, and sometimes may need to be, subtracted. The controlled test may be neither cause, nor symptom, but simply a part of the development of medical science into a practice that neglects the role of meaning and symbol in human biology.

The effects of these aspects of human life have been left to the less embodied practices of psychology and psychoanalysis, where instrumentation is not nearly so prevalent as in biomedicine, the realm of the extended and the fixed.

The origin of the placebo effect

In the account of instrumentation developed in Chapter 4 the range of different forms that constituted experimental set-ups and that could be considered to be instruments, (whatever their material form) was discussed. Latour and Woolgar's (1987) definition of inscription devices as forms of instrumentation need not necessarily include physical machinery (such as a 'statistical institution' that gathers information using a range of methods). Central to the function of the instrument is its production of an inscription that is linked to the material world. The inscription comes to be the marking of, established by argument and demonstration, a state of the material world. Central to the this account of instrumentation is the understanding that, it is not a function of the material device that qualifies a system or activity as an instrument, but its arrangement as a rational structure, incorporating protocols and logical inferences regarding the causality and relatedness of phenomena.

It is with this understanding of instrumentation in mind that the controlled trial is discussed in the following section of this chapter. What characterizes the controlled trial is the particular protocol that it puts into practice in order to establish the relationship between changes in the human body, and things that might affect it (chemicals, medicines, food or exercise for example). The controlled trial is discussed in the thesis because it has been identified by authors such as Moerman (2002) as a site of discord that creates a tension between how different forms of biological causality are understood.

The controlled trial serves to exemplify how instrumental apparatus and protocols can be used to demonstrate, or obscure, organic aspects of human physiological function, the human body's responsiveness to meaning, the symbolic, and the subjective. Integral to the controlled trial, is the use of 'placebo', deceptive dummy treatments. This has led to the coining of the term 'placebo effect', used to refer to the healing experienced by trial subjects who are not treated, but respond instead to the meaningful circumstances of receiving the placebo.[102]

In controlled testing, the 'placebo effect' has come to stand, by synecdoche, for a range of unwanted bodily changes or experimental anomalies that may affect the outcome of a clinical trial. It has been the subject of ongoing dispute between alternative medicine and allopathic medical practitioners since the 1950's about the effects of 'mind over body' and the relevance of this knowledge to medical practice. The alternative medical critique of allopathic medicine is that it takes an engineering (mechanical and chemical) approach to the discovery and treatment of disease and its interactions with the patient. In this discussion, the placebo response comes to

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[102] For a good explanation and a number of examples of the placebo effect in action, see Moerman (2002).

signify what is denied by biomedicine. However, the 'placebo effect' is produced by the instrumental logic of the controlled trial (Frenkel, 2008). As the following description of the history of the controlled trial will show, the idea that biomedicine denies certain aspects of the human, subjective experience of treatment for example, is somewhat inaccurate. The alternative suggested by the following, as well as the discussions of medical practices in chapter 5, is that it is not the purpose of instrumental protocols designed by biomedical science to separate these aspects of human response in order to deny them, to dismiss their objective reality. Instead it seems more likely that this is done because they are considered external to its realm of interest and intervention.

Whatever the reason the placebo effect tends to be discarded by orthodox medical practice, the link between biology and meaning, and the way in which it has been worked upon in different ways using instruments, shows part of the history that explains the way in which the instrumental has become closely linked with the production of accounts of the human body where the meaningful and the symbolic and the material and biological are brought into contrast, or separated from one another. It is the argument of this section, and the next chapter, that tests like the controlled trial and other forms of instrumental apparatus can be used to either deny or to materialize aspects of the immanent interior of the subjective body, such as the imagination.

It is the position of the thesis (as clarified in chapter 1) that an extended materialist interpretation of the body as an embodied subject means that the human body might be less accurately described as responding to meaning, and better thought of as *itself inherently meaningful.* It is worth re-iterating Moerman's point that the meaning effect is no more paradoxical than 'smiling when we see a puppy' or 'crying at a sad movie' (2002). Smiles and tears are just as biological as the immune system and pain receptors: sadness and sentimentality are still as mysterious and difficult to see connecting to facial anatomy and tear ducts as to any other cellular or organ system. This interpretation means that there is no longer a need for a conduit or explanation for the process of meaning to have an effect on the body, such as classical conditioning or expectancy theory.[103]

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[103] The concept of classical conditioning best known through Ivan Pavlov's well-known experiments with dogs conducted in the 1920's. The animals were trained to salivate at the ring of a bell by repeatedly accompanying feeding time with the sound of the bell. B.F. Skinners experiments in the 1940's with rats similarly used food rewards to train them to undertake certain actions - for example, pressing levers. The behaviors that were instilled in these animals were explained by the theory of conditioning, which offered a basis for an early behaviourist account of learning. Many of the early descriptions of how conditioning related to learning and cognition in animals are now considered to have been overly simplistic, and the theory is now generally considered as an anachronism (Gregory, 1987, pp.159-6). In terms of the placebo effect, conditioned responses appear to offer some explanatory power in terms of the unconscious bodily responses to stimuli observed in some placebo responses.

An account of the placebo response based on conditioning might reasonably propose that the act of taking a tablet or being given an injection could be related to a specific treatment outcome by repeated linked experiences of the phenomena, a patient might come to associate an injection of morphine with relief from pain. However this neat causality becomes less firm when other stimuli that elicit placebo effects are considered, could this simplistic account of conditioning explain the differing responses to differently colored tablets, to knowledge about a condition, or expectation of the content or action of a specific treatment which have not been conditioned by previous experience. Evidence that patients do respond to this kind of information show that while conditioning might offer an explanation for some placebo effects, it is inadequate to account for many of the characteristics of the phenomenon.

Contemporary Psychology has responded to this deficiency in classical conditioning to

Through an examination of the early history of controlled testing, its rationale, and structure, this section demonstrates how an instrumental system, and a philosophical conception of the human body, its subjectivity and its materiality relate to one another, and to an extent have become co-defining. This section will look at some key points in the history of the emergence of controlled testing as a methodology, with reference to its use in clinical trials of medicines, and at the way in which the instrumental 'cuts' invoked by the original interpretation of these trials appear have produced pervasive effects upon what is considered to be meaningful in medical practices. Controlled medical trials produce a circumstance in which the imaginary and symbolic power of objects and actions, and the experience of them, is intentionally

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suggest expectancy theory as an alternative account that can incorporate the cognitive aspects of patient responses to, and experiences of, treatment situations. Expectancy theory posits that conscious awareness, cognition and expectation regarding the outcomes and effects of treatments allow patients to put into action stimulus responses from existing conditioning. What expectancy theory lacks is a mechanism for its influence on physiology, as it incorporates a psychological cognitive model of the patient as they formulate an expectancy based not only on prior experience but on conscious knowledge. Classical conditioning avoids this problem by neglecting an account of the psychological realm, the relationship between stimulus and response are contained within a simplistic account of the organism, and therefore the conceptual and causal breach between psychological expectations and physiological actions is not dealt with. However, as Oron Frenkel asks; 'But how do you get from mental state to body?' (Frenkel, p.63).

Frenkel's paper, *The Phenomenology of the Placebo Effect* (2008) recasts the placebo effect as a bodily affordance. He distinguishes his notion of affordance from Gibson's in that Gibson's affordance is a cognitively derived reading of an object's design, whereas Frenkel is more concerned with a phenomenological notion of an affordance being the meaning of a particular thing in a particular circumstance, far more contingent. Frenkel responds to this failure of psychological accounts to explain meaning response phenomena - conditioned responses cannot account for the full range of effects of the meaning response, and that expectancy - in that the patient expects a certain medical outcome from an intervention - simply invokes a conscious awareness of a situation, but does not provide any model of how this awareness might impact upon the patient's physiology.

divorced from the chemical or mechanical aspects of a treatment. This is done because the imaginary and symbolic count amongst a number of external aspects of receiving a treatment that might affect the biological outcome and physiological behaviour of the body. However, as will be discussed below, the way the results of these experiments have been interpreted shows how instrumental systems and apparatus can be used to connect or disconnect certain aspects of human subjectivity and experience from the objective, material and instrumental realms.

Structure of the controlled trial

In contemporary medical research, the 'gold standard' is 'evidence based' medicine, which aims to extensively test medicines and medical procedures prior to their adoption in clinical practice. Experimental verification as a practice arose in the new sciences of the late 18th and early nineteenth century Europe.[104] In medicine this represented an intellectual move away from earlier traditions of more dogmatic physicianship (Harrison, 2004, p.48).

Clinical trials are usually split into a number of groups or 'arms'. One is

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[104] Until very recently in history, within the last century, the efficacy of a medical treatment was more often than not established through a process of reasoning, in line with particular models of the body's organisation and its tendencies. Many models which explained the body's structure and function, such as the Greek system of humeral medicine, which foregrounded a physiological and balance centered medical perspective, persisted - mainly unquestioned - in medicine from antiquity up to the 16th Century (Porter, 1999).

the treatment group, who receive the new drug or other treatment being assessed (sometimes called the 'verum' – Latin for true). Patients in the treatment group can be subdivided into further arms that receive different doses of the medicine being tested such as 10, 50 or 100mg of a drug, or other variations of the treatment. Traditionally there is also a control arm, the members of which serve as a comparison. Subjects in this arm are given the existing medicine for a condition, or a placebo, such as inert tablets. In contemporary trials, the dispensing of the drugs and placebos is done 'blind', so that neither the doctors nor the patients are aware of who is being treated with what, or how much of it. Throughout the trial the patients are usually monitored and assessed and tested in various ways in order to assess the effects of the medicine. When the trial period is over, the study is 'unblinded' and the true details of the medications they are receiving are revealed. The aim of this process is to prevent bias in either the patients or medical staff assessing them. In some studies there is also an untreated group, referred to as a 'natural history' group, who receive no treatment at all.[105] Sometimes there is a marked difference between the outcomes for natural history (untreated) groups, and the placebo group, which is understood to be the result of a response in the patients to the experience of treatment, rather than the physical effects of their

[105] Moerman (2002) and others have pointed out that the effects of regular interaction with medical staff and assessments using technologies, for instance the reading of blood pressure done regularly, has been shown in trials to have the effect of lowering the blood pressure of patients. This effect would be similar to that of 'white coat hypotension' – 'the phenomenon of having a high blood pressure when it is measured in the clinic by a physician but lower blood pressure levels in everyday life' (Steptoe, 2007, p.700).

'inert' medicines.

Mesmer, Lavoisier and Franklin

In 1784 Louis XVI, responding to pressure from the Parisian medical community, ordered a Royal Commission to investigate the medical claims of Anton Mesmer. Mesmer's medical treatments were devised around the notion of a magnetic 'subtle fluid' that he and his disciples manipulated in the bodies of patients, according to his theories of 'animal magnetism'. Mesmer's interventions claimed to restore the natural balances of this magnetic fluid in the body. His treatments used a variety of methods, metallic instruments, baths of iron filings, magnetized iron rods and powdered glass which were rubbed upon or held onto the patient's bodies, and the exertion of animal magnetism over the patient was effected by trained practitioners, often by touching with the hands. Mesmerism become extremely popular in Paris in the five years after Mesmer arrived there in 1778. The authorities had refused him a license to practice medicine when he first arrived, but to circumnavigate this Mesmer set up practice with one of his disciples, Charles Deslon, who was an already registered physician. His practice became exceedingly popular amongst Parisian society, both Mozart, and Mary Antoinette counted amongst his clientele (Herr, 2005, p.347).

The Royal commission consisted of a team of eminent experimenters, most famously Benjamin Franklin, who at the time was serving as the

American Ambassador to the French King's court, and Antoine Lavoisier. Working together to establish their aims and method, the commission set up and embarked upon a number of experiments, with the cooperation of Charles Deslon. Many of these experiments used deceptive measures intended to confirm or disprove the existence of the force of 'animal magnetism' which Mesmer claimed was at the centre of his treatments.

The Commission explained its logic in the document it produced on the results of the study, *Report of the Commissioners Charged by the King to Examine Animal Magnetism* (Franklin, 1837); "Animal magnetism might well exist without being useful, but it cannot be useful if it doesn't exist". The intangible nature of animal magnetism initially meant that the team's attempts to establish or disprove its existence or not were thwarted, as they tried to measure its presence in the tools that Mesmer used. Both an electrometer and a compass found no electrical force or magnetic fields. They also attempted to sense the effects of animal magnetism themselves, by being subjected to the treatment, but felt nothing. It was Mesmer's response that the force could only be measured through its effects upon living organisms.

Performing trials where the various possible causes of the effects of mesmerism were separated and independently tested, the commissioners concentrated its efforts on establishing the circumstances that generated episodes in the patients called 'crises'. These crises were characterised by fainting, fits and convulsions in patients during treatment, which had been explained by Mesmer's disciple Deslon to be signs of healing. Mesmer himself refused to assist in the study, as he disagreed with the Commission over which effects of animal magnetisms would be useful to test. Mesmer suggested that the experimenter's attention should be focused upon the beneficial effects of the treatment - upon the cures effected by it, rather than its apparent immediate effects upon the patients which could be observed in during the treatment sessions. The commission disagreed, maintaining that cures by mesmerism could not be separated from other effects external to animal magnetism, such as the natural effects of healing.

The hypothesis of the commission was that the crises might be either caused by the effects of Mesmer's subtle fluid, or by psychological suggestion, and set out to differentiate the effects of these two in a series of 16 experiments. In one, a blindfolded woman was told that she was being treated with mesmeric power by Deslon, and she accordingly demonstrated the effect of the crisis, they repeated this test without a blindfold, and she suffered another crisis when told that Deslon was treating her from outside of the room. In both cases, Deslon was not present at all. The crises were considered to have been caused by the power of suggestion of mesmeric treatment rather than actual mesmeric treatment. The Commissioners also performed experiments where subjects were magnetised by Deslon without their notice or given magnetised water as if it were normal water. In these cases the patients did not respond with crisis symptoms or other awareness that they were in contact with objects containing mesmeric power.

Satisfied, the commissioners concluded that;

Crises are caused by suggestion, not a shred of evidence exists for any fluid, and animal magnetism, as a physical force, must be firmly rejected. The practice of magnetization is the art of *increasing the imagination by degrees* (my emphasis) (Franklin, et al., 1785, p.349).

There are a number of reasons that the commission's conclusion might have been premature,[106] however, what is important to consider here is the

[106] For example, while the suggestion was causing the crises in these experiments was logical, the failure of Deslon's attempts to magnetise subjects without their knowledge, and through magnetised materials could be attributed to his own shortcomings as a mesmerist. More importantly, as Mesmer appeared to have understood, the commission's interest in crises rather than cures only established that crises were caused by suggestion – not that the claimed cures effected by mesmerism were bogus. The commissioners conveniently accepted the relationship that was suggested between crises and the effects of animal magnetism, but while this link might be reasonable to assume, it is not logically necessary for there to be a physical relationship between these phenomena. Mesmer may well have healed patients as well as having the showmanship to provoke an unrelated faint or fit.
Equivalently – as shown by psychological expectancy theory (which is often evoked in discussion of placebo phenomena) a tablet which regularly makes a patient vomit may well, if an inert version given, still cause them to vomit. The emetic qualities of the tablet however, may be entirely unrelated to its other medical properties. In the same way, crises could be a psychological side effect of the social situation and events where mesmeric treatment takes place. Mesmer's – and indeed Deslon's – treatments might well have still effected a beneficial healing change in the bodies of patients, perhaps one that was not immediately apparent. While the commission's experiments were certainly extremely damaging to Mesmer's claims, what they ultimately proved was not the non-existence of animal magnetism, as they claimed, but that crises were not caused only by the intentional actions of the mesmerists, but that the responses of the patients to the idea of treatment by mesmerism were crucial to the precipitation of these crises. Crises in themselves might only represent the willingness of the patient to be healed, and the responsiveness of the patient to the act of healing, the active desire of the patient in the process of healing, rather than the manipulation of the patient's body through the effect of a force which could be measured with a compass or electrometer. It is also illogical to conclude that the failure of the commissioners to measure Mesmer's magnetic power using these instruments signifies its non-existence, there are numerous phenomena which are considered objectively real, light for example, which cannot be sensed magnetically or electronically. What these attempts demonstrated was that Mesmer's description of his force as 'animal magnetism' was misleading as a choice of terminology, not that it was necessarily non existent.

Understandably, regardless of these criticisms, a number of academics, including Stephen Jay Gould, have described the commission report as – in H.W.Herr's words, 'a key document in the history of human reason' (p.348). It may commission's immediate denial of any possibility of the imagination being related to healing. In the contemporary view, dismissing the effects of the imagination might seem an established and orthodox way in which to respond. However, as the following sections of this chapter will show, at the time of the commission, other experimenters and physicians were still willing to consider, and impressed by the results of the power of the imagination as a healing force.

The 'fair trial'

James Lind, physician and pioneer of naval medicine, was another innovator of controlled testing, what he referred to as a 'fair trial'. Lind's 'Treatise on the Scurvy' (1753) reported the results of his test of a number of scurvy medicines and cures on his crew whilst at sea, which he undertook while working as a ship's physician. These tests included a trial in which sailors who were clearly suffering from scurvy were given one of a range of treatments, seawater, elixir vitriol, vinegar, oranges and lemons, and a mixture of nutmeg, garlic and horseradish (Bollet, 2004, p.178). While Lind's test is noteworthy as an important innovation in medical history, his attitude to the results of these tests and the mechanisms of cure that he discusses in his treatise on the work are worth noting.

In his treatise, which is commented upon by Haygarth (1800), Lind

have been groundbreaking for its time, but while the commission's report puts a good case against Mesmer's claims, it certainly fails to refute the healing effects of his practice, and operates on a number of assumptions, the first of which, it appears, that Mesmer was a charlatan.

relates Dr Van Der Mye's report from the siege of Breda in 1625, at the end of the Eighty Years War, where the Prince of Orange's garrison were reported to have been healed by;

> [...] three small phials of medicine [...] not enough for the recovery of two patients. It was publicly given out [...] The effect, however, of the delusion was really astonishing; for many were quickly and perfectly recovered. Such as had moved their limbs for a month before, were seen waking the streets sound, strait and whole. They boasted of their cure by the Prince's remedy [...]

Lind continues;

> [...] an important lesson in physick is here to be leaned, viz. the wonderful and powerful influence of the passions of the mind upon the fate and disorders of the body. This is too often overlooked in the cure of diseases; many of which are sometimes attempted by the sole mechanical operation of drugs, without calling in to assistance the strong powers of imagination, or the concurring influences of the soul. Hence it is, that the same remedy will not always produce the like effect, even in the same person, when given by different hands (Lind, in Haygarth ; 1800, pp.28).

Whilst Lind was notable for his innovations in the modern practice of medical testing, his comments about the 'powerful influence of the passions of the mind upon the fate and disorders of the body' (ibid) are worthy of note. Franklin, Lavoisier and the other commissioners not only used placebo (sham) treatments in their trial, but they also dismissed the alternate efficacy of these treatments by relating them to 'convulsions' but not to cure. Their approach to the Mesmer trial was therefore not only an innovation in 'rationality' but was also notable for its dismissal of a force that was a commonplace aspect of medical treatments at the time.

Early modern physicians; empiricism and placebo

Lind was by no means exceptional in his acceptance and interest in the role of the 'powers of the imagination' in healing. Many physicians who performed the early experiments to empirically test medicines knew and made use of the effects of placebo in their day-to-day medical practice. An early appearance of the term 'placebo'[107] in a medical context is in the late 18th century, in 1772, in the transcripts of lectures made by a popular physician of the time, William Cullen (1710-1790) (Kerr, et al., 2007). Whilst the term is relatively modern, the practice to which it refers, of prescribing inert preparations, and the idea that those 'sham' medical interventions might have an effect upon the body via the passions, sympathies or imagination of the patient and so stimulate healing - or at least the illusion of it, are ideas which are centuries old. Family doctors have given placebo medicines such as bread or sugar pills, coloured aspirin tablets (Porter, 1999, p.681), saline injections or drops of coloured water as commonplace and harmless palliatives, to difficult patients, or when there was no better alternative available ; providing placebo was considered an entirely defendable and humanitarian act, in fact, to offer ones patients what comfort was available a duty of the paternalistic physician (Kaptchuck, 1998, p.1722).

Historically, placebo treatments have been considered as a 'benevolent deception' to calm patients and offer those whose conditions were chronic,

[107] The word placebo, from the Latin 'I shall please' dates from the 14th Century, and originally referred to hired funeral mourners, who the deceased's family members would pay to lament on their behalf (de Craen, A. J. M., et al., 1999, p.511).

untreatable, or whom needed the comfort of a deceptive treatment. The effect was often considered to be consistent with and attributable to the credulity of the patient (de Craen, A. J. M., et al., 1999, p.511). However, a number of early modern physicians who observed their patients and performed small scale empirical tests during the course of their clinical careers made observations of, commented on, and exploited the effects of mental phenomena on physiology in their clinical practice. The way in which they incorporated the notion of psychological assistance in medical treatment, as they observed what would nowadays be referred to as placebo effects or responses is an interesting mixture of attitudes that accepted these phenomena as simple common sense.

Cullen developed and wrote about a treatment methodology that he called 'active placebo'. This treatment used pharmacologically active substances, such as mustard, which he judged would be conducive to an improvement in the patient's temperament – and suited to the particular malady from which they were suffering. While these treatments were not a proven treatment for the disease being treated, by their use, Cullen aimed to generate what he called a 'sympathy' between himself and his patient. In this, his approach to medicine combined what we might now consider to be physiological and psychosomatic medical approaches.

John Hunter (1728-1793), who has been referred to as the 'father of modern surgery' (Moore, 2005) was another innovator in the use of 'natural experiment' to assess the efficacy of many treatments of his day. His work is notable partly because of the attention he paid to other aspects of healing which are associated with placebo groups in controlled trials (not only the 'meaning effect' noted by Moerman, [2002] which relates to symbol and knowledge) such as regression to the mean, and the natural tendencies of the body to heal unaided.

Hunter began his investigations whilst a surgeon in the British army. Taking a sceptical attitude to received medical theory regarding the removal of bullets and shrapnel from wounds. He, unlike his contemporaries, left musket balls and other debris in place, and found that his patients recovered better than those who underwent surgery to remove them. This improved prognosis was most likely due to the soldiers whose wounds went untreated not being exposed to the risk of infection in the highly unsanitary environment of the battlefield hospital (Moore, 2009, pp.1-2). Throughout his later career as a private surgeon and lecturer on anatomy in London, Hunter continued to experiment on himself, his patients and animals, remaining a firm proponent of experiment and observation as the best route to reliable knowledge.

In her commentary on his *A Treatise on the Venereal Disease* (1788) Wendy Moore (2009) has explored Hunter's views regarding the effects of a patients mental state upon illness (pp.1-2). At his private surgery Hunter specialised in the treatment of these illnesses and undertook to test on his clientele the relative effectiveness of mercury and bread pills (a commonly prescribed sham medicine) as a treatment for gonorrhoea. His investigations showed that while mercury was known to cure syphilis, it was a no more effective treatment of gonorrhoea than bread pills. He wrote that 'time alone will effect a cure' (pp.69-70), concluding that the eventual resolution of the illness that sometimes appeared to be the result of patients taking mercury was in reality due to the disease running its natural course – the illness being *self limiting* in nature. He observed; 'The patients always got well, but some of them, I believe, not so soon as they would have done, had the artificial methods of cure been employed' (ibid). Moore points out that while the term placebo itself does not appear in Hunter's writings, 'he was well aware of what we now refer to as "placebo effects" – both in orthodox medicine and folklore alternatives' (Moore, 2009, p.3). Hunter's early modern commitment to an empirical approach, experimentally confirming the efficacy of treatments, led him not to dismiss, but to observe the effects of mind as a medically relevant factor in treatment, asserting that; 'as the state of the mind is thus capable of producing a disease, another state of it may effect a cure' (Lind, 1788, cited in Moore, 2009, p.3).

Haygarth's trial of metallic tractors

Another notable test of a medical treatment that claimed to use mesmeric power was performed by John Haygarth in 1800. Haygarth's experiments were possibly the first to use a deceptive 'sham' placebo treatment. His trial was a test of a popular medical device known as 'Metallic Attractors' or 'tractors'. These *tractors* were an offshoot of Mesmer's medical claims, and had become popular in health spars at the end of the 18th century.

During the treatment, the metal-pronged implements were run along the skin of the patient as a treatment for a number of maladies, often arthritis and rheumatism. The beneficial effect of the tractors was held to be a form of mesmeric power or animal magnetism exerted by the metal components upon the body.

Haygarth's comments on the results of his placebo treatments are revealing when compared with those made by the commission involving regarding the comparable trials they made to investigate Mesmer. In both studies the experimenters observed what would be considered, in a contemporary setting, to be a placebo effect, which they refer to as the effect of the imagination. The Commission dismissed these effects because they were only caused by the influence of the imagination. In contrast, Haygarth concludes that while the tractors themselves were a sham, the powerful effects of the imagination are clearly very important.

Haygarth's findings led him to write and publish his pamphlet *Of the Imagination, as a Cause and as a Cure of Disorders of the Body; Exemplified by Fictitious Tractors, and Epidemical Convulsions* (1800). Here he reports the method he devised to test the tractors, which involved the substitution of a set of metal tractors for wooden replicas, a variety of different kinds were used. The sham tractors were used in the same fashion as the regular ones, by doctors at Bath Hospital and Bristol Infirmary to treat a number of patients, who were mostly suffering from rheumatic illness, in Haygarth's words, 'a very obstinate and permanent disorder' (p.5). Despite this, in the first trials of the 'false Tractors', three of the five patients treated were 'remarkably relieved'. The experiment was then recreated by a contemporary of Haygarth's, Richard Smith at Bristol Infirmary, first with pieces of wood carved to appear like the Perkins tractors, and then later – in Smith's words, 'to render the trials the more ridiculous' 'pieces of bone', 'pencil' and a pair of 'tobacco-pipes painted' (p.13). In all cases that Smith reports, patients that are unable to lift limbs, or suffering from considerable pain, all are remarkably relieved by the applications of the fictitious Tractors. Haygarth's response to this is noteworthy;

> The facts above related are sufficient, and more than sufficient, to discredit the supposed virtues of metallick Tractors; but the success of the trials, both at the Bath Hospital and Bristol Infirmary, brought more important objects into view. They prove to a degree which has never been suspected, what powerful Influence upon diseases is produced by mere Imagination [*sic*] (p.16).

Haygarth's reaction to the effect of these placebo devices is interesting in that he does not attempt to make a distinction between the observation of an improvement in the patient made by the medical professionals present and the patient's subjective *imagined* experiences of treatment and recovery. Instead, he points out the importance of bearing these kinds of effects in mind.

Summary

It was the confluence of a number of factors which meant that during the 17th and 18th centuries, changes in ideas about human physiology led to physicians spending more time developing material and mechanical explanations for diseases. The acceptance of the theory of the circulation of the blood, and the popularity of approaches such as iatrochemistry (a school of medicine which aimed to explain disease and design treatments based on the developing techniques of analytical chemistry) led to a medical attitude which attempted to provide more detailed causal accounts of disease (Brockliss, 1978, p. 238). During this period, as scientific materialism became popular, the idea that the actions of what Haygarth called the 'imagination', might be of any value for medicine lost popularity, replaced by increasingly mechanistic explanations. It appears that as forces such as this imagination lost their physical, if somewhat amorphous nature, and no longer considered immaterial or pseudo-physical, a vocabulary for a common sense explanation of mental-physiological interaction became increasingly unavailable.

When enlightenment models of mechanistic causality came into fashion physicians still openly discussed and admitted to using placebos but they were mostly understood as a sham rather than as any mechanism by which healing could be achieved. It was not until the 1950's that a concept of placebo comparable to the early modern ideas of Cullen, Hunter, Lind and Haygarth regarding the power of the imagination re-emerged.[108]

These examples show the interdependence of the experimental conditions of any trial with the possibility of meaning or imagination having an effect on the body. Lavoisier — pioneer of the new mechanistic chemistry –

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108 Henry Beecher's influential paper *The powerful placebo* (1955) reintroduced the notion of a 'placebo effect' as a problem for medical testing. A fuller account of the effects of Beecher's work is included in appendix.

disavowed the imagination without a thought. Haygarth and Lind, in distinction, interpreted the results of similar trials as showing the importance of the imagination in medical treatment. Cullen and Hunter were also alert to its existence through their own clinical studies and made use of its effects in their medical practice.

It is the position of the thesis, as explained in chapter 1, that immaterial phenomena such as culture, meaning and the symbolic are not only partially implicated as shaping factors in the formation of the biological body, but are ontologically inseparable from it. Meaning, experience and physiology are coextensive. The placebo effect appears to offer evidence of the relationship between meaning and biology in the arena of medicine, and also that its is not just longer term effects of cultural norms for example, that shape human bodies, but that in the short term, the way in which human bodies manifest responses to meaning can be recorded. Commentators on the placebo effect like Moerman and Frenkel hold that the placebo effect is only a paradox if an unnecessary distinction between the materiality and the meaning are maintained. Combining an extended materialist ontology with the evidence from studies of the placebo effect, as well as Moerman's synthesis to define the meaning response, suggests an extra dimensionality to the way in which we conceptualise the relationship of objects and instruments to the body. Instrumental testing, if viewed in a certain way, allows the body to expand beyond the boundaries of those phenomena that we consider to be physical, it simultaneously endows the symbolic and the physical with new properties.

Chapter 7. Measuring meaning and the imagination

This chapter extends the themes of chapter 6's discussion of the controlled test and the imagination. It introduces two further examples of instruments, the lie detector test, which is performed using a polygraph machine, and the automatograph, a 19th century psychological instrument invented by a well known American psychologist named Joseph Jastrow. These examples, and the discussion that frames them, illustrate the argument of the thesis regarding the relationship between instrumentation and the body. The discussion will particularly seek to clarify the thesis' notion of the way in which instruments can be seen to materialise both interiors and exteriors of the human body, a subject that was introduced in the previous chapter's discussion of the way in which controlled trials produced or discarded the imagination as an active force within the body in early modern medical experiments. It does this in order to write the apparatus into the definition of bodily materiality and meaning that is established in chapter 1 and complete the work of the thesis.

Certain aspects of instrumentation and its relation to the body are revealed by these two examples. In particular they stress the material-discursive nature of instruments and also their ability to materialise or frame phenomena by setting up certain experimental protocols. These examples exemplify and offer a further grounding for understanding instrumentation and its relationship with the human body established in chapters 4 and 5. In chapter 5, a survey of some examples from the medical humanities literature offered an insight into way in which the sense of reality of the body wavers, bringing into being, or metamorphosing certain phenomena. In the production of various body phenomena, instruments are important agents. It is examples of how different kind of human phenomena can be created by instrumental practices outside of scientific settings that this chapter seeks to further elucidate, by turning to another field where instrumentation is applied to the body, jurisprudence.

The rationale for using deception detection as an example is partly that it offers another setting for understanding instruments in use, in addition to the medical applications already discussed in the earlier parts of the thesis. It is also, like the placebo effect, a site of controversy, it is considered by many as untrustworthy, unscientific, and overused (Andreassi, 2006, p.420). However, lie detector testing remains a major area of applied psychology, particularly in the United States, used in both law enforcement and personnel and security applications, privately and by federal government organisations[109]. Despite the prevalence of the practice, these tests are currently inadmissible as evidence within the U.S. Supreme Court. Within academic psychology, lie-detection is the subject of controversy, with much scepticism towards its value. While a number of meta-analyses of studies investigating lie-detection have been done, they take varying positions on its value (pp.420-3).

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[109] Andreassi (2006) notes the F.B.I, (Federal Beaureu of Investigations) C.I.A. (Central Intelligence Agency) and N.S.A (National Security Agency).

Lie-detection testing uses a number of protocols to create particular settings and inferential links between physiological response, knowledge and behaviour. Therefore, like the randomised controlled trial, it offers an insight into how different aspects of test subjects are included or excluded from different testing situations, how different phenomena, both subjective and objective, are framed and materialized by instrumental practices. The reading and interpretation of lie-detector tests is a skilled job, and a practice that attempts, rather boldly, to infer interior knowledge or emotion, from a complex of clues, not simply the output of the machine. In a sense, the protocols that surround the test provide a foil within which it is possible to explore the relationships with the subjective, meaningful, and the symbolic found in applications of instrumental measures of human bodies.

Using the example of controlled testing, and the placebo effect that it produces, chapter 6 illustrated the way in which instrumental systems can be used to generate and exclude certain aspects of subjective, psychological reality from the causal and material reality of the body. A discussion of the history of placebos and the understanding of the role of meaning and imagination in medical treatment showed the interplay of scientific and epistemological agendas with the understanding of medical cause, legitimacy and ontological categories.

The automatograph will serve as an example that links the history of experimental psychology with lie detection, but will also serve to link in a speculative fashion, back to the denied history of the placebo effect, and the role of the imagination as a force in the human body. Jastrow described it as a device that could be used to show 'the direction of the imagination' marked in the form of an inscription on smoked paper or cylinder. The second part of the chapter will discuss, in a somewhat provocative fashion, how Jastrow's words might be understood, in their reference to this technologically simple device, allowing very different interpretations to the intentions of its inventor based on an alternative ontology of the human body. The influence of 19^{th} century scientific materialism on Jastrow's thought, as well as its more general effect on the development of experimental psychology, has been charted by historians of science (Daston, 1978). A discussion of the automatograph will give an opportunity to consider the continuing influence of decisions and ways of thinking about instruments that were established during this time.

Using the examples of the lie detector and the automatograph, this section will show that an onto-epistemological reading of instrumental apparatus allows the construction (production or evocation) of phenomena that are not tied to the concept of bodily materiality that is traditionally associated with instrumentation. All three of these examples are ones which are surrounded by certain levels of controversy, as we have already discussed the way in which certain instrumentation such as thermometers and blood pressure measurement are successfully incorporated into the production of phenomena which can be seen to be less than materially solid, as well as historically contingent. In this section we will look at examples which are contested, as this chapter will argue, because they each appear to incorporate some element of meaning within the phenomena which they demonstrate, and are therefore open to a critique regarding the material relation of the phenomenon they produce to the instrumentation that measures it.

The lie detector test

The following discussion of the use of the polygraph machine for lie detection explores the role that can be taken by deception as part of, as well as the object of, an instrumental system. The lie detector test is incongruous, in that it requires the use of deception in order to detect a deception. The term 'lie-detector test' refers to the test rather than the instrument used to perform it, the polygraph machine. The test itself may make use of a set of protocols and methods for variously establishing incriminating knowledge or guilt on the part of the test subject. During a lie detector test, a polygraph machine is used to record the physiological responses of the test subject to various stimuli. Literally, 'polygraph' could refer to any machine that records more that one type of data (Andreassi, 2006, p.421). The test is must be performed and assessed by a trained professional, because the test is not performed by the machine alone; some scholars, such as Bunn (2007) consider the instrumentation to serve little more function than as a prop.

Detecting deception has a long history. The ancient Chinese gave suspects rice powder to chew during questioning, as intense fear inhibits salivation, Hindu medical texts from 900 BC record that signs of falsehood were the touching of hair or blushing (Andreassi, 2006, p.421). William Marston attempted the first instrumental detection of deception using measurement of systolic blood pressure in 1917 (Cappicio, 2008, p.688). His work attracted the attention of two police officers, Larson and Keeler, who between then developed the 'Keeler Polygraph', which measured electrodermal activity, blood pressure and respiration (Andreassi, 2006, p.421). These responses are all understood to correlate more generally to the state of the autonomic nervous system, involved with physiological excitement and fear, therefore understood to response to the stressful nature of lying.

While automatic software systems are available which give a probability reading of the truthfulness of a subject's statements, tests are still hand scored, for reasons that will be discussed in the following (Cappicio, 2008 p.688). Tests are usually for one of two reasons, in criminal investigations, 'specific incident tests' may be used, which refer to specific events being investigated. 'Screening procedures', in contrast are more speculative, and are used to gage the level of security risk posed by a potential employee for example, and attempt to ascertain the likelihood of test subjects harbouring undesirable inclinations, intentions or predispositions. There are a number of testing protocols that have been developed by the various law enforcement agencies and companies which use polygraph testing. In forensic investigations there are three prevalent methods for performing the test 'control question technique' (CQT), 'directed lie technique' (DLT) and 'guilty knowledge test' (GKT) (Cappicio, 2008).

Each of these testing protocols, incorporates hardware components as well as these methods by which the test is performed. The readings of the polygraph machine have no meaning until they are cross-referenced with the test protocol and the stimulus which the subject is being exposed to. In a sense deception testing has similarities with Randomised Controlled Trials and the way in which they are performed, there is a protocol, or a number of protocols, which are the set of actions that control the particular situation in which readings are taken from the subject. In the case of the lie detector test, the distinction between the appearance of a scientific experiment and the authority of the technological apparatus becomes a crucial part of the way in which the subject is prepared for the performance of the test.

In the 'Guilty Knowledge Test', subjects are shown an array of items, or key words, one, or some of which are linked to the crime for which they are accused. If the physiological records show a response to one of these stimuli, the subject is considered to have shown that they recognise the object in question, (which may count against them if it is the item implicated in the crime). Other forms of test use control questions designed to elicit a 'flat response', or to make records of the subject lying about other unconnected information before the start of the test. These preparations and setups make it clear that the way in which the test operates is much wider than the apparatus. The subject must be carefully prepared and managed within the context of the experiment. Countermeasures, such as 'wiggling a toe' or 'imagining being slapped' (Cappicio, p.697) can be used by (and taught to) subjects of these tests in order to make their responses to incriminating stimuli appear normal.

Lie detection as performance

Bunn's paper *Spectacular Science: The Lie Detector's Ambivalent Powers* (2007) surveys 20th century news, magazine, movie and comic and television and advertisement references to the lie detector. He argues that the representation of the lie detector as a formidable technology was instrumental to its functionality as an instrument. The instrument is;

> [...] on the one hand, an automatically functioning machine, the epitome of science. But on the other hand, the lie detector is also a totemic object that requires the skills of a charismatic magician to work at all (p.156).

In Bunn's formulation, through its recognition in popular culture and news media as an infallible technology that produces a certain proof of guilt or innocence, the lie detector exerts a 'spectacular mode of governance'. As one news report he cites reports 'a lie detector was carried into the death cell and scientists, lawyers, jailers and witnesses stared at tiny needles tracing on a slowly moving paper ribbon what proved to be *mute lines of doom*.' (my emphasis) (Bunn 2007, p.156) Here we see described the tracings of nature marking out, what must be, to the trained eye of the Professor performing the test, incriminating evidence against the convict. This description, and the machine it describes, is without qualification, the machine does not speak, there is no discourse between the test subject and the instrument, which as a 'mute' witness, draws out inscrutable tracings what is nothing less than 'doom'. However, as Bunn puts it the 'lie detector had an air of menace about it– and deliberately so', he, like contemporary supporters of the lie detector test, suggests that the test might be more accurately considered as a form of torture (p.161). Hugo Munsterberg (whose early experiments with the physiology of deception were picked up by Marston) was supportive of the use of the machine as an alternative to the 'third degree' (pp.160-1) the practice of torturing suspects until they confessed. The polygraph was seen as a welcome non-violent alternative.

As Bunn notes, this inbuilt threat, and the way in which it was supported by the theatrical nature of the test is central to understanding why Leonard Keeler, who pioneered the use of the polygraph in detecting hidden physiological responses that might signal guilt, would have suggested that those performing tests with the machine should prepare subjects by giving them a short talk at the outset that assured them that the machine was 'quite safe'. This kind of talk can be seen to operate in a number of ways, to prepare the authority of the test giver, to introduce the – if not already sensed – concept of the machine as a *possible* source of danger. Being told that something is safe references the notion that safety might, or might have in other circumstances been an issue, even if that *particular* machine is now considered safe (this is similar to the way that a nurse might say 'don't worry this won't hurt a bit' is a preparation for a painful procedure). In addition to this preamble about safety, assurances about the accuracy of the machine would also be made. This system of codified practices and recommendations regarding the way in which the tests were carried out are testimony to the theatrical nature of the procedure. Its being likened to the third degree also shows how the machine was considered most useful for its ability to extract confessions without letting blood, as subjects became more and more convinced that their guilt was being laid bare by the device, their fear and agitation would eventually lead to them voluntarily admitting their guilt. Bunn's argument is that while the symbolic function of the test is central to its usefulness, this was because its function is that of torture – forced telling – rather than as a method for 'reading'; the lie detector test is sham science.

However, there is no reason to suppose that the subject of the test, as well as the device are read together. Attempting to resituate the discussion of the lie detector alongside Barad's work on measurement, and her description of measurements as practices which *perform* a 'cut', deliniating what is, and what is not of interest, what parts of the world are, and are not measured. The suspect's response is the phenomenon that is produced by the test, the question that this begs, is how to interpret the meaning of the response, both that observed by a human and that observed by the device drawing out its 'mute lines'.

The test might be understood as a staged performance of difference. The lie detector's dual status as a machine, and also as a piece of theatre, illustrates the mixed nature of instrumental setups, and the way in which instrumental practices incorporate and impose meaning onto matter. This insight allows the discussion to develops a number of themes, particularly that of the roles of imagination and meaning within the realm of the instrumental.

This description of the lie detector test shows how the technical authority and symbolic power of a device can be seen to function as part of its workings, as an integral aspect of its functioning as an instrument. The discursive and performative dimensions of the device are central to the effect that it produces, not only a side effect. As Bunn observes, the test is more ritualistic than scientific, however perhaps we might extend his argument, to claim that this ritual is central to the device rather than essentially different to what it pretends to be. Even when it becomes clear that the test is reliant on deception, it retains its instrumental structure, and renders visible its reliance on its own meaning in order to function.

Historically, the rhetoric attached to the use of the polygraph for lie detection described the machine as 'writing'. It produced an inscription that was considered to be a legible, fixed and unambiguous evidence of guilt, similar to the clarity and revealing window-like nature of the MRI scanner of the popular imagination. The objective machine speaks for itself. Here, as is the case with many technologies, the work of scientists and lawmen to decipher the meaning of these inscriptions is overlooked in favour of presenting the apparatus as self reliant and infallible. While users of complex technical systems are more than aware of the challenge of gaining reliable information from complex scientific apparatus, the fact that these devices are difficult to use is seen by outsiders as further confirmation of their technological complexity and sophistication.

The importance of the symbolic dimension of the lie detector test to its instrumental function offers an example of how instrumentation can be understood to function outside of the 'objective' and material dimensions to which instruments are usually thought to belong. Thus the polygraph offers an example of a tool that does not show the body as it 'really is', does not, 'enlighten', but instead infers and suggests, that offers links between the unseen knowledge of its subject, the subjective dimension of the experiencing, embodied subject. The lie detector test is a technology that invokes interiors, truths and relations and knowledge are pulled into material being like threads of evidence. The performance, meanings and knowledge themselves form part of the bodily technology that may not be separable from the material and mechanical aspects of the machine.

Lie detection technology has been very strongly critiqued as being unreliable and unscientific. However, the set-up and experimental protocols of these devices could be understood to exist on a continuum of reliability alongside other experimental and instrumental practices. The lie detector experiment is more unreliable, and also attempts to infer the unverifiable. The thesis is not concerned with the question of whether the technology is sufficiently robust to be used in real world applications such as law. However, the lie detector test can be seen to operate on the body in the way the Wittgenstein's philosophy suggested was possible, a body where the interior is legible, because the psychological and subjective are an integral part of the material body and indivisible from its behaviour.

Joseph Jastrow's Automatograph

The final section of this last chapter will turn to a device called the 'automatograph' – a psychological instrument devised in the late 19th century by the experimental psychologist Joseph Jastrow. The device itself is simple, made from two wooden frames containing panes of glass laid horizontally one on top of the other. Between the two panes sit 3 brass bearings of ¾ of an inch diameter. The top of these panes of glass is attached by a thin metal arm to a glass scriber, the scriber is positioned over smoke blackened paper or glass onto which it marks a graphic recording of the experiment.[110]

In order to use the automatograph, the subject places his or her hand gently on the top pane of glass, and lets it rest there lightly. They are instructed to try not to move their hand. The instrument and the hand are screened from the subject's direct view by a curtain. Then the experimenter conducts their test, one devised by Jastrow involved the subject looking at items moving around the laboratory in front of him, or thinking about objects in different places. As the subject does this, his hand moves involuntarily, the smooth nature of the glass and the bearings in between mean even very tiny

[110] Smoke blackened paper or glass was a common laboratory material in the 18th and 19th centuries and was used to make graphic recordings as part of a range of apparatuses.

unconscious movements are translated to the blackened paper of glass via the arm and scriber. The movements of the subject were then recorded in the form of an inscription on the surface of the glass or paper, which could be studied at leisure.

Manifesting the inner; the inscription of thought

In a popular science magazine of the time, Jastrow' explained the value of the automatograph via the claim that 'thought is repressed movement' (Jastrow, 1891-2, p.398), experimental psychologists used the device to make graphic recordings of what Jastrow described as the 'unconscious movements' of the subject's hands. As an experimental psychologist, Jastrow had a particular interest in the detection of deception (Pettit, 2007). The automatograph offered a way in which to render visible the unconscious and involuntary movements of the subject, and could be used in a similar way to the lie detector to discover whether a subject had prior knowledge of the position of an object hidden the laboratory, for example.

Jastrow's description is beguiling, the idea that the automatograph records the 'movements of the imagination' seems to suggest, with a non-reductive interpretation, that there is something more subtle that can be deciphered from the inscriptions made with the automatograph, as if they were a form of abstract expressionist gesture. If it can be considered that the act of imagining a particular place internally can be translated to an inscription, then perhaps hidden within the images created by the device are other aspects of the imagination's expression in the body, even in its most tiny form.

While this interpretation would have been exactly against Jastrow's views of the importance of rational and empirical science in psychology, the device, it can be argued, makes clear a mechanical relation between the subject's subjective interior, to use Jastrow's own term, the unconscious, and inscriptions produced by the machine. This relation to the interior is both an obvious, and oddly overlooked aspect of the relationship between machine based graphical output and the internal subject-hood of the subjects of measurement. Implicit in the automatograph's apparent mechanical simplicity is a claim to render visible the unspoken and interior life of the patient. Therefore it is possible to situate the automatograph in a broader discussion of types of human function, signs and behaviour and their manifestation in material instrumental practices.

Summary 'Imagine being slapped'

In the earlier description of the lie detector test it was noted that certain methods, known as 'countermeasures' could be used in order to fool the test during the calibration process. Alongside 'muscular movements', such as 'wiggling a toe', 'changes in breathing', or 'self induced pain' a subject of the lie detector test might 'imagine being slapped' (Andreassi, 2007, p.242; Cappiccio, 2008). Whilst all of the other countermeasures involve some direct manipulation of the bodily physiology, "imagine being slapped" seems to stand out for its reference to an imaginary state. The basic clarity of this link between an intentional, if imaginary state, and its use to fool a instrumental device suggests that the direct relation between the imagination and the device, and the ability of the human mind to produce physiological states though the exercise of that imagination might be described, rather simply.

Chapter 8. Understanding instrumentation as creative practice: poetics and the physiology of the imagination

This final chapter clarifies the intention and contribution of the thesis by making clear the impact of the ideas that it surveys and synthesises from the history and philosophy of science and technology, and the medical humanities, on the use of biosensor and biometric instrumentation in creative practices. It explores the implications of the concept that bodies and instruments emerge together from a process of co-construction, and how such a concept might be exploited using a method already central to artistic practices, the poetic. Such a notion provides a context to explore how the creative arts themselves are already equipped with a methodology to act on and make use of the opportunities for reimagining practices which incorporate bodies and instruments as creative, and that the thesis has assembled a convincing account of instrumentation and human physiology which support this claim. By showing that the concepts of instrumental 'mechanical' objectivity, that are commonly ascribed to automatic measuring apparatus, are not the only model for understanding what biosignalling apparatus offers, the thesis instead offers a synthesis of theoretical literatures that supports an alternative model of instruments that incorporate the imaginary, symbolic and meaningful as active participants in the evocation and description of physiology. This alternative model offers a clear theoretical scaffold and examples (such as the symbolic aspects of polygraphy) to support practices involved in the construction and imaginative use of biosignalling technologies.

The following discussion of poetics and the physiology of imagination will show how the thesis builds upon the observations of the philosophy of science and technology, and history of medical technology to show that the change to how instruments might be understood has a material impact upon how we might understand physiology within creative practices. The following provides the final move of the thesis, framed by a question that emerges from the thesis' discussion of instrumentation and bodies; what ontological models might now direct how creative practitioners approach the use of biosignalling instrumentation?

As the thesis' review of the literature of philosophy of science regarding instruments has shown, remaining open to an understanding of instrumentation as reconfigurable as well as productive suggests that using and creating measuring instruments might be seen as an active intervention in how the body is experienced and thought about, both on a cultural and an individual level. This can be considered as a broadly relativist approach to understanding scientific instruments and medical practices, the way the world appears depends upon who you are, and where you are standing, and also, why you are looking. The devices that we build to aid in our practices of measurement are just as likely to incorporate certain 'lenses'. The contribution of the thesis lies in how this position is responded to, in that it generates an account that might be meaningfully applied as an argument for certain approaches to understanding instruments. The thesis assembles and explores concepts of instrumentation that do not separate the material from the meaningful, drawing on examples of actual practices – which while not themselves within the arts – can be seen to use instruments in ways that go beyond the understanding of them as devices for objective and scientific measurement.

If we are to understand instruments as frames for the way in which we come to experience and think about the body, then it follows that by creating them, we make certain decisions about how to depict the body and what is important about it, what to draw into the fore by the construction of certain devices. Making use of technologies most usually associated with the sciences, and scientific medicine, artists may find themselves adopting and reinforcing the rhetoric associated with the scientific and medical practices concerned with establishing their method for making use of instruments, as well as the systems of psychology and physiology that these devices are used to monitor. In revealing that doing this involves certain responsibility in that it has certain effects, the question is then raised – how might these practices be understood and acted upon as creative? How might the effects of meaning on the body discussed above be successfully incorporated into a way of thinking about the creation of instruments for measuring and representing the state of the human body? By offering this discussion of instrumentation and the body, the thesis contributes a position from which creative and cultural practitioners might reconsider their own relationship with instruments – particularly biosignalling technologies.

The thesis assembles its answer through a synthesis of ideas from the history of medicine and accounts of the co-construction of medical instruments and body. It draws attention to particular themes, in particular the imaginative and poetic aspects of the body, and the way in which scientific techniques and technologies can be understood to interface with it.

The following chapter is primarily concerned with exploring a possible analogy between instruments, as ways in which we might represent the body, the experiences of embodiment and language – in particular poetic language. The following passages therefore aim to suggest that applying the ideas that inform poetics to the understanding of instrumentation previously developed in the thesis might offer a way in which to conceptualise the potential of working with and using instrumentation in a relationship with the body that suggests more complex intra-actions and creative interventions and inventions.

Chapter 8 clarifies how the thesis has built an alternate way of understanding instruments - but it also offers a way of understanding the method of poetry as an existing response to understanding the co-construction of embodied experience through practices of describing (and reifying) phenomena. Therefore poetics and the imagination exist as an excellent model with which to consider instruments that offer experiences such as biofeedback, offering a method for practice (both in the arts and outside) and points towards and existent - and rather convincing manifesto for the pursuit of this way of thinking which will impact both on how artists use sensing equipment, but also other potentially creative uses of instruments to measure human bodies[111], such as by medics and technologists working in HCI.

Poetics as a way to deal with constructedness

As described in chapter 2's discussion of scientific epistemology, a rhetoric of objectivity has traditionally accompanied thinking about instrumentation. The following section will offer the notion of poetics as an alternative method for conceptualising creative uses of instruments. As we will see, Richard Rorty, an important informant for the discussion in chapter 2 of the way in which philosophy has been associated with particular models of truth that have impacted upon the epistemology of science, proposed poetics as a possible approach made possible by the rejection of a concept of philosophy as a search for accurate language in which to describe reality. Rorty's pragmatism compels him instead to use poetics to remind us that of an alternate understanding of language from that proposed by positivist philosophy. He argues against the notion that philosophy should be concerned with the use of language as a device that reflects (mirrors) the world around us,

[111] It is not necessarily the case the observations of this thesis should be limited to a modification of our understanding of body sensing in human, and not animals, or in fact, beyond physiology in biology as well. A discussion of this type is currently beyond the author's knowledge, however, Evelyn Fox Keller's (2002) work regarding the use of models and metaphors in the life sciences is an excellent start for readers who would pursue this topic.

a device that through successive revisions might come to more and more closely reflect the true reality in which we find ourselves. This project has been adopted by the sciences, and similar models – discussed in chapter 3 – inform thinking about instruments, proposing that they are devices which can give access to an authentic body, that techniques such as automatic data registration offer a greater 'accuracy' to reality. As an alternative to this, we might adopt Rorty's tactic of developing an account of poetics that stands against a model of language and 'truth', and instead proposes that the co-constructed nature of instruments and bodies, as described in medical anthropology and history of medicine, might be considered to be an opportunity for practice.

Poetics can be understood as a method for dealing with the commitment of language to invention, and to the generation of new ways of speaking that might be understood not only to describe more accurately the experience of life, but the potential, through inventing new descriptions, of changing the possibilities for experience itself. The following discussion of poetics will primarily draw upon Richard Rorty's synthesis and exploration of poetics as a method for responding to the potential opportunities offered by philosophical pragmatism – which like constructivism, considers there to not be a *best* way to describe the world or one's own experience of being, but that instead there are a multiplicity of ways in which the world and ourselves might be described, and that one outcome of this is that the innovation of novel vocabularies provides an inherent human freedom, and responsibility. Rorty's understanding of this project is inherently political, and this is not a point that should pass the reader by in reference to the discussion of instrumentation. Instruments, through their automaticity, apparent objectivity, naturalness and scientific authority, by becoming associated with a 'true' body that we must learn to understand ourselves by, for example understanding the body as a genetic machine, or as a set of organ systems, allow ideological structures that inform the designs of systems made for particular purposes, to come to stand for the truth of those experiences. Poetics not only shows us that in the same way that language has been critiqued by philosophers for being a structuring and inherited system that reinforces particular ways of making sense of the world, so these devices might do the same to our experience of embodiment. Poetics then, is the practice, the method, for breaking out of this relation.

The commitment to a poetic interaction with the world is therefore the result of a particular aspiration on the part of the speaker/writer. As described here, this desire is two fold in its analogy with instruments that depict the body through measurement practices. First, when we speak, it is understood that we use language that already exists, unless we invent new words or ways of speaking. This process is always linked to history and to our existing language practices, but the poet's aim is to break out, to innovate, upon the inherited and inherent way of speaking that we each acquire as part of our heritage. The second idea is somewhat more profound, and explains the deep importance of the first. This is that when we speak, and most particularly, when we describe the state of our internal experience, of what it feels, subjectively, to be alive, or even, to be dying, we use, and therefore shape and reinforce, aspects of our experience. Description and experience are understood to be reciprocal.

If, we think about instruments and the phenomena that they manifest as co-constructed in a similar way to language, then the principles that are suggested by an account of poetics in language might also have relevance to instrumentation. Instruments, particularly those used for biofeedback, describe the body to us by the phenomena that they demonstrate as part of it. This is not simply that instruments register and signal change in the body to us, but that certain aspects of the body come to attention, to 'matter' in Barad's terminology.

As discussed in chapter 3, the thermometer is an exceptionally good example of this, as the device was slowly reified, the notion of bodily heat changed and metamorphosed, and with it, the potential for explaining, and measuring aspects of experience and embodiment, and, as my argument holds, experiencing a particular aspect of embodiment. The analogy with language is therefore clear. Instruments can be seen as analogous with words, they are forms that we use to make shapes of the world.[112]

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[112] These changes in the possible nature of bodily experience are not only a concern for those of us who are interested in describing a phenomenology of instrumentalised experience. While this is certainly interesting area of interest, and one that is being explored variously in the philosophy of technology, health psychology etc. It can already be understood that technological invention and medical interventions that are introduced into our lives do not constantly add to a stream of modifications of the 'lifeworld'. This thesis has consciously avoided responding too closely to this set of issues, while as a research topic these issues have been of interest and have informed

Rorty's discussion of poetry

In *Philosophy and the Mirror of Nature* (1980) Rorty talks about Gadamer's development of the notion of 'edification' as a form of 'self-making'. He describes it as a;

> [...] project of finding new, better, more interesting, more fruitful ways of speaking. The attempt to edify (ourselves or others) may consist in the hermeneutic activity of making connections between our own culture and some exotic culture or historical period, or between our own discipline and another discipline which seems to pursue incommensurable aims in an incommensurable vocabulary. But it may instead consist in the 'poetic' activity of thinking up such new aims, new words, or new disciplines, followed by, so to speak, the inverse of hermeneutics: the attempt to reinterpret our familiar surroundings in the unfamiliar terms of our new inventions. (p.360)

While some tactics of edification include reflection on other cultures or histories, or the reflection upon an outside discipline with incommensurable aims, a final method for making new and 'fruitful ways of speaking' is to take a poetic approach, and to attempt to innovate and reinterpret. The notion of poetry as an approach to making sense of a world that does not take reality as a given but something that, pragmatically, we must develop a language – and one of many possible languages, to deal with, was explored by Rorty in a number

the work. The aim of the thesis has been address instrumentation from a more external perspective, not only focussing on the role of experience. The reason for this is the thesis' goal in providing an analysis of instrumentation itself, when we enter the phenomenal world as the site for an investigation, the apparent importance of the objectivity and world representing nature of instruments is lost, and this is something that the thesis has sought to maintain, mainly in order to demonstrate that there are alternatives to this way of thinking about instruments.

of the texts he wrote throughout his philosophical career. He uses the notion of the poetic as it has been explored by a number of philosophers to suggest how one might live productively in a world where there is no 'best' way to describe reality, in a world where reality, and the self, is part of an interaction, and one that must be treated as an opportunity for creating the world afresh.

Rorty's discussion of poetics provides an alternative to what he calls the 'classic picture of man' in which;

> The notion that our chief task is to mirror accurately, in our own Glassy Essence, the universe around us is the complement of the notion [...] that the universe is made up of very simple, clearly and distinctly knowable things, knowledge of whose essences provides the master-vocabulary which permits commensuration of all discourses. (1980, p.357)

The model of the world that makes this possible is one that is *knowable,* graspable in its fixity and simplicity. However, Rorty concludes that this notion of the world is absurd. Language, and I would advance that also, technologies – cannot, and should not be considered as capable of being commensurate with a fixed truth about the world.

In *Contingency, Irony, Solidarity* (1989) Rorty re-introduces his earlier critique of analytical philosophy's tendency to consider language as something that might reflect nature – providing a medium for the 'Mirror of Nature' that he critiques as a model for how human knowledge relates to 'authentic reality'. These themes of mirroring and authenticity can be seen throughout the literature regarding instrumentation and mechanical objectivity, demonstrating a realist position with regards to these technologies. It is here that Rorty offers poetry as a way to think about the possible alternative model for the project of philosophy, not as an epistemological project to describe how true knowledge is arrived at, but to explore the edges of what is possible to think and do. He suggests, following Nietzsche, that poetry is the one way that man can break out of a trap made by his own culture, to 'make himself' to be truly different and that without having achieved (or at least attempted) this, life is truly futile (pp.23-9).

A particular understanding of reality is necessary to allow us to apply Rorty's idea about language to our discussion of instruments – although the ideas area already historically linked by particular scientific epistemologies. Crucially, the thesis understands language as any form of meaningful structure or valence that shapes experience. It understands that a notion of a 'prenoetic'[113] interaction with reality is essentially an impossibility, because this kind of 'prior to language' supposes that there are parts of human beings that do not structure the world.

In this, the discursive can be understood as part of a wider way in which human beings are situated within the world, and respond to it in human, and meaningful ways. Language is often considered to be more clearly understood, it gives the appearance of having a meaning that is separable from the physical

[113] The term prenoetic is used within phenomenology and cognitive science to describe the structuring aspects of consciousness that happen 'before we know it' (Gallagher 2005 p.2). Such a structuring is seen as inaccessible the reflective consciousness, as such it is maintained that both conscious and cognitive processes; perception, memory, imagination, belief and judgement, are shaped or structured prenoetically. (ibid)

body and the world that produces it, an apparent quality of abstraction. This separation is hard won, it is carefully constructed, not a simple thing. The human body and the world have as many different noetic interactions as there are organs of the body, cell systems, families, ideas. The body is part of an embodied and embedded complexity, not the support system for a being that internally represents the world using language as a sign system.[114]

With the discursive and meaningful fundamentally in the material, as established in chapter 1, we are led to consider the concept of the poetic, its relevance to understanding instrumental descriptions of the world, and the meaning of the phenomena found within it. If we take the position that language is fundamentally embodied, this modifies how the making of poetry is considered. Poetic creation is not an abstract activity, the re-description of the world, and the body, becomes, in the schemes of theorists like Barad, Schleifer, and Mol, an utterly material practice which is part of wider practices of human performance and action.

Poetics and instrumentation[115]

A speculative view of how instrumentation can be developed as a

[114] As discussed in chapter 1, Wittgenstein, Rorty, Grosz and Schliefer offer critiques of this model.

[115] The temptation to use the phrase 'instrumental poetics' here is strong, however, there is not the scope for an investigation of what this concept might mean in the space available in the thesis. However, Schleifer's conceptions of the materiality of utterances combined with an analysis of Winch's discussion of instrumental action might, in future be an interesting area for speculation on the materiality, intention and use of spoken language.

creative practice might also make use of Rorty's notion of the poetic, 'new aims, new words, new disciplines' (p.360) might offer us a change to create our 'familiar surroundings' of the body as 'unfamiliar'. The discussion opens up some philosophical territory that shows how the thesis suggests a return to a consideration of the relations between instruments, language and human concepts of reality, and leads back to phenomena and marks. By making the analogy between the making of instruments and the writing of poetry, a space is opened up that seems brimming with potential for a way of dealing with instruments which is informed by the definition of instruments produced and supported by this thesis. Instead of instrumentation being useful input and connection devices allowing artists to represent bodies by making multimedia applications controlled by biosignals, or by producing visualisations based on data from the body, this way of thinking about instruments suggests that a far more radical intervention into the experience of embodiment is enabled by the development and use of these kinds of devices to make artworks. In particular it suggests that the representation of the body by these devices should not be tied to a pre-existing anatomical or physiological 'truth' that exists prior to the development of instruments, models, or other representations. The model of technological co-construction of devices and bodies allows those working creatively with technology to reconsider their relationship to these technologies as essentially innovative and productive. The concept of a poetics of instrumentation is not offered as a final solution, but more as an articulation of an alternative approach to understanding what is enabled by these practices. It can be seen as a suggestion of a far more developed and analogous practice that instrument making might be compared with, which stresses its potential creativity as a radical break from predefined concepts of the world, and yet still maintains its existing technical forms.

Poetics and the Imagination

Richard Sha's 2009 paper, *Toward a Physiology of the Romantic Imagination* 'seeks to recover a physiological imagination' (p.197) overlooked in the history of the Romantic period. This recovery, mirrored by the research of the thesis discussed primarily in chapter 6, does not only suggest something that might be returned to, by way of an anachronism, a return to a now out –of-date thinking. Instead it can offer a freeing up of the possibilities associated with instruments, an opportunity to recover perspectives lost in the formation of disciplines that may make more sense to practices like the arts.

Many of the historical accounts discussed in the thesis Sha's, Daston and Galison's, and my own historical discussions of the placebo effect, take into account the historical contingency of the psychological and physiological sciences formation in the early modern period – as practices committed to the development of scientific methods of enquiry, such as controlled testing – still retaining models of the imagination as a physiologically and medically active force, and therefore one which was open to the influence of instrumentation as well as detectable by it. As pointed out in chapter 6, the invention of the controlled trial marks a historical point at which the active nature of the imagination was both constructed as, and first made separable from medical practices, a move which later led to the formation of a concept of the 'placebo effect' which construct meaning as a separable and unimportant aspect of embodiment. The following will provide further weight to the concept of the poetic as a method for reinterpreting arts practices using instrumentation by reiterating and recovering the mechanism for this.

Sha's discussion of the 'romantic imagination' provides a further link with the imagination of the romantic poets and his observation that the imagination transforms 'materiality into a site of possibility'. While his discussion is focussed upon a particular historical position – there are aspects of it that suggest that the imagination is one aspect of the bodily that provides a link between the material and the ideal. Many of Sha's observations about the role of the imagination in romantic period physiology encourage a reading of the dual potential of uncovering an ideal and poetic approach to understanding the way in which instrumental technologies might be used on the body. He returns to the nascent science of physiology and the way in which imagination was incorporated into physiology;

> Even as physiology attempted to make a science out of the living as opposed to the ideal, it turned to concepts like life, predisposition, and potentiality to give the imagination a curious immaterial materiality, one that made materiality as site of possibility rather then determinism (p.197).

Sha seeks an alternative, as prior to this, historians have considered the ideological aspects of the romantic imagination, and that its association with physiology was generally held by scientist's and medics writing during the period, who, Sha observes, considered the imagination to be entirely 'pathological'. The historical literature on this theme of imagination also takes on these ideas, in distinction, Sha points out that "while these studies emphasise pathology, [he is concerned with] physiology, pathology's double." (p.198)

What Sha is interested in is the way in which the imagination was used to render the material potentially vital and a 'site of possibility', and the way in which romantic poets responded to certain ideas about physiology with their exploration of the powers of the imagination as much as this exploration might have been prompted by ideological concerns.[116]

Rather than dismiss the imagination as little more than 'ideological escapism',(p.198) Sha points out that tales and warnings of the pathological consequences of excessive imagination function more to suggest a reading of the imagination as intended by Haygarth and his contemporaries, whose identification of imagination as active upon pathology, rather than undermining its objective status, instead cements it, "making unassailable the imagination's ability to change matter. Even when diseased, the imagination's

[116] Sadly there is not the space or time in this thesis to fully develop the potential links between the ideological function of the imagination and its relationship to not only the emergence of new sciences (shown in Sha's work and also in the problems surrounding early experimental psychology) but also the emergence of new technologies, all of which demand a resistance against determinism.

hold over the body paradoxically gave it powers of transformation"(ref). The imagination, therefore – cannot be discarded as simple fantasy, but in fact, the acts and creations of the poetic imagination are materially and physiologically effective.

The thesis' discussion in chapters six and seven regarding the effects of the imagination upon the body – and its role in eighteenth century constructions of instrumental objectivity and rational systems for body measurement, relate a conception of the imagination as an active and material force (for example that it produces the placebo or meaning effect) is mirrored by Sha's history of the imagination in physiology, as opposed to what he considers to be a general concern with its status as ideological force within Romantic thought, or as pathology. Sha argues, that the importance of the imagination in medical thought is as a faculty that, by its disorder might produce disease, provides an undeniable link to the physiological qualities of the imagination in these systems of thought. In addition to its powers for producing pathological, and bodily symptoms – amongst them the malformation of the fetus according to the mother's imagination – or even her belief in the power of her own imagination to effect such malformation, the imagination also provides a positive explanatory force for the healing effects of placebo treatments for physicians such as Haygarth and Lavoisier – regardless of their interpretation of its potential use.

We might, of course, be cautious of the convenient flexibility of the concept, which may be moved between ideal and conscious states and physical functions such as digestion with a lose ease. As Sha notes; " the imagination has always rushed in to fill the gaps between materiality, and what technology can deliver as materiality, making the imagination inseperable from physiology" (p200), it is the imagination's "ambiguous ontological status"(p.204) that prevents us from having a clear conception of the physiology of the imagination. While it encourages caution, the relations of a poetic and imaginative realm of instruments might be faithfully reinstated. These might be considered valid criteria for the rationalisation of instrumental qualities of the body. There is an idealism therefore open to how we work with instruments – which – through the positioning of physiology and imagination as intrinsically and materially linked – we achieve validation of different outcomes and processes

The physiologically active imagination therefore complements the poetic notion of instruments. Both offer a break from the overly rationalised and instrumentalised understanding of the role that measuring instruments might play in their interaction with the body. There are critiques of this idea, as discussed above, it might be perceived that language, unlike the hardware of biosignalling equipment, is unfixed and flexible in how it is combined and innovated. However, the concept of poetics developed in the thesis (particularly with reference to Schleifer) counters this reading of language as distanced or separable from the body, and in order for it to have bodily meaning, it must connect and resonate with embodied life. Instruments themselves, we might argue, are capable of being dematerialised much more than we might consider (as discussed in chapter 4 with regards to Latour's concept of instruments). Thus the thesis proposes a possible flexibility afforded by instrumental protocol, meaning and body. Much of this flexibility can be recovered in the Romantic notion of the imagination as physiologically active. As Sha observes that: "Such flexibility within physiology allowed the material to be about conditions of possibility, and once again aligned the material with Romantic idealism (p.207).

The accusation of idealism could appear to undermine the account that the thesis assembles; however, an idealism of physiology might also be interpreted as a useful tactic to 'free up conditions of possibility' as Sha puts it. As shown in the history of 20th century medicine and onwards as one of defining and seeking the normalisation of the body's state (Canguilhem, 1989) it appears necessary to rebel against this understanding of particular 'natural' ideals or forms that are the ideal to be sought after, with the aid of medical technologies that might monitor and remind us of how far we are from those norms. Instead, the idealism of the thesis is concerned with encouraging the imaginative exploration of the possible bodies that might be created, and reminding us that the way in which these technologies are involved in the reinforcement and seeking of norms is in itself an imaginative practice, there is no 'normal' or 'natural' body. If the account within the thesis is therefore to be critiqued as being idealist – un-tethered from the brute facts of human physiology, there is an underlying goal to this, which is that it is intended as an antidote to the effects of the rhetoric of scientific epistemologies which have claimed instruments as objective devices which afford us a mirror in which to see our 'true' nature. What it in fact represents is an antidote to materialist understandings of the response of the body to meaning and offers a resurrection of the Romantic imagination as an active physiological force. Hence the discussion shows that a poetic approach to instruments is enabled by these links between physical devices, imagination and meaning, and the physiology of the body.

Summary

Rather than being a solution to a particular problem in human body instrumentation, poetics is invoked in order to draw attention to the potentiality which is evoked by the construction of instrumentation, which in a universe where the phenomena of the world are not given, but are evoked by actors, human or otherwise, it might be more useful for some of us to think of instruments as material forms of poetic and creative practice.

By applying an account of poetics to a discussion of instrumentation and the imagination, this chapter has shown how we might suggest, instead of the instrument as analogue of the real, the instrument as practice, a practice with creative potential as a form of intra-action with the physiology of the body. It addresses the issue regarding what values might shape our actions, and attempts to draw attention to the poetic potentials of understanding how practices using mediums other than spoken language might invoke the imagination to impact on physiology. Discussing Sha's historical observations on the historical understanding of the imagination allows it to be made clear how the thesis recovers a particular way of thinking about human physiology in order to exploit the creative possibilities of instrumentation.

Conclusion; Overview of the thesis

> Philosophers should free themselves from scientist's scepticism, and instead conceptually anticipate the final goal (Gustav Fechner, *in* Heidelberger, 2004, p.144).

The underlying goal of this thesis has been to assemble and develop a theoretical account of human body measurement technologies that can support creative practices that use those technologies. The thesis builds on philosophical projects that reject the orthodox scientific understanding of instruments as devices that can 'reveal' the world and instead explores how instruments can be considered as technologies that allow human beings to co-construct aspects of the physical world – with particular reference to the human body. The thesis develops a number of key ideas relating to how this co-construction can be understood, and upon which a number of approaches to understanding human body sensing instrumentation as an artistic practice can be formulated.

To do this the thesis identified relevant theoretical sources in order to explore the meaning of instrumental technologies in a way that is relevant to arts practice. Drawing attention to alternative ways of thinking about instrumentation to the orthodox epistemology of science which positions instruments as objective, the thesis provides a synthesis of the neglected role of the imagination and poetics in the physiology of the body. Exploring examples of how these forces can be identified in instrumental practices, such as in placebo experiments and the lie detector test, provides a key to understanding how a poetic and essentially creative approach might be applied to understanding the use of instrumentation in the arts and in the creation of artworks as well as the creative development of technologies.

Instrumental sensing and the arts

As the following sections will show, many of the arguments developed in the thesis are highly pertinent to arts practices that aim to make use of biosignalling technologies as well as other instrumental systems that measure the body. The thesis provides a necessary transfer and synthesis of scholarship from many relevant fields, to the arts.[117] It is envisaged that the ideas assembled, recovered and synthesised by the thesis will offer an interpretative lens for researchers and artists working with instruments that interface computers with the body (for example in Human Computer Interface research - HCI). Many artists have, and continue to use, biosignalling devices and other forms of sensor as controllers in new media art installations and performance

[117] It is worth keeping in mind that the problems and opportunities revealed by these discussions of creativity and human representation and categorisation are by no means limited to the kind of mechanical instruments discussed by the thesis. In fact there is more literature (some of it drawn upon here) that focuses up on the human science's production of categories and their effects upon experience and concepts of self (readers might refer to Hansen's 1992 work on homosexuality discussed in chapter 5).

(for a review of these practices see Brouse, undated). The ideas collected in this thesis offer a framework that situates these practices with reference to a range of other disciplines, particularly the philosophy of technology, and provides a transfer of scholarship from the history and philosophy of science and technology that might be useful to artists seeking to examine the epistemological and ontological context of the technologies with which they are engaged.

In particular it is envisaged that the thesis might offer insights that will aid emerging arts practice concerned with the exploration of technologies and the way in which they can be used to modify human life as their medium. The increasing ubiquity of sensors and mobile computing power is likely to lead to further opportunities for artists to make use of these technologies – the thesis offers a description of potentials – illustrated by the thesis' recovery of ideas from scholarship in the history of medicine and medical construction as well as a development of the concept of instrumentation as creative and unfixed. These offer a ways of reinterpreting and conceptualising possible practices that use instruments to measure the human body. They remind us of the rhetoric that has historically been attached to scientific technologies such as human body sensors and provide conceptual tools for the assessment of concepts of instrumental objectivity, reality and authenticity which should enable critical approaches to sensor technologies in the arts.

This approach to technology also impacts elsewhere, scientists and technologists need to be aware that the activities in which they are engaged are creative – Richard Rorty's critique of the 'mirror of nature' in philosophy is therefore applicable to our contemporary sciences and may serve to remind us that if we move to a model of co-construction rather than of revelation using scientific technologies, these ideas also impact on the production, design and application of sensor technologies for HCI. By arguing that Rorty's observations about poetic language can be extended to the instrumental, the final chapter of the thesis chapter clarifies how the poetic might offer a method for practices using instruments that understands them as engaged in the construction of experience through practices of describing (and reifying) phenomena. Therefore poetics, and the imagination, offer conceptual tools with which to consider instruments that offer biofeedback as a method for practice (both in the arts and outside). What poetics also offers is a rather convincing manifesto for the pursuit of this way of thinking that will impact both on how artists use sensing equipment, but also medics and technologists working in HCI.

The thesis reviews the history and philosophy of science and medicine, in order to contextualise these discipline's approach to instrumentation as linked to particular requirements of practice rather than essential to their use. The thesis also proposes poetics as an existing methodology central to arts practice as a method to deal with and understand the possibilities (poetic and constructive) enabled by creating systems that human represent bodies. As articulated by the thesis, 'romantic' and 'imaginative' approaches to thinking about instrumentation and the bodies which may be produced by it do not invalidate the use of instruments, instead, the synthesis of relevant scholarship in the history and philosophy of science and technology provided by the thesis supports the argument that there are in fact dimensions of instrumentation which are intentionally obscured in scientific practices. For example, the placebo effect is manifested by the need to manage the body's response to meaning in experimental testing. Rather than consider meaning and symbol as external to the intended 'work' of instrumental technologies, it may be more useful to consider that 'work' as being context specific, in some practices, such as the arts, the role of meaning and the ability for it have an effect upon instrumentation could be central.

In the first chapter the thesis provides a review of philosophical perspectives regarding the human embodiment of, and response to, meaning that give shape to this observation about instrumentation. This theme is revisited throughout the thesis in its discussion of the role of meaning and imagination in the placebo effect; as it is manifest in contemporary medicine; in discussions of, and research into the placebo effect and lie detector test; also historically, from both primary and secondary literature, regarding the establishment of early research into empirical medical testing and the way in which the imagination was considered to be physiologically active in a material sense. The understanding that the body contains an active material imagination serves to inform how the physiological possibilities of sensing are themselves imagined by potential users. The result is a creative, poetic approach to body sensing, rather than one that is constrained by existing phenomena or interpretations of them.

The aim of this discussion has been not to contribute a prescriptive guide to particular outcomes, but to offer a set of arguments and examples which taken together builds an alternative account of the instrument and its interaction with the body that in might offer certain advantages as a theoretical underpinning for artistic practice.

Non-determinism and technology

One important outcome of the thesis is that it argues for an approach to sensor technologies, their use and design, that is non-determinist. It does not lead creators using or innovating with sensors to rely upon particular concepts – but stresses the creative potential for generating novel analyses of body state. When looking at the way in which technologies have developed in relation to the phenomena they manifest, it is easy to rationalise what they do post-hoc, and to consider those phenomena as pre-existing, rather than, as aspects of the world that are evoked and co-constructed in collaboration with instruments. The effect of this is that it is necessary to remind ourselves that the outcomes of instruments and the development of these technologies is not necessarily dependant on what is already waiting to be discovered about the body – but is more radically constructed.

There are a number of ways in which the thesis supports this idea. First, it provides an overview of the medical humanities observation that bodily pathologies and states are constructed rather then pre-existent phenomena. Work like Duffin's histories of disease concepts is explored, to examine how instrumental and medical setups produce disease as phenomena in many different forms. Drawing on Duffin's account of two apparently very different diseases, that of lovesickness and hepatitis C, the thesis gives an account of the historical and instrumental contingency of disease and other bodily and cognitive phenomena that, it can be argued, are the result of forms of instrumentation. By doing this, the thesis unlinks the practice of sensor design and use from already identified bodily phenomena, and instead suggests that these instruments themselves are central to the apparatus that produces phenomena.

Historical contingency and technology

Non-deterministic approaches to technology suggest other ways of thinking about the development of instruments. They allow the thesis to discuss alternative ways of understanding the development of instruments to that offered by the 'whig historical' approach of people like Silas Mitchell, who was dismayed at the length of time that it took for physicians to adopt the practice of pulse counting. Both SCOT and ANT approaches allow creative thinkers to move away from the assumptions that technologies change along, if unpredictable, lines of constant development leading to one 'best' way of dealing with reality. As the histories of pulse reading and thermometry attest – such as Reiser's observation that doctors were disinterested in thermometers because they could not give an account of the 'qualities' of heat, and were therefore an inferior form of patient monitoring – this taken alongside Terry Castle's observations regarding the romantic and poetic treatment of thermometers and barometers devices which were interpreted considered to be highly sensitive devices for measurement, which had access to the sensibilities of those who made the measurement – the alternative possible outcomes of the development of an instrumental system might be better understood as *different* rather than better.

An awareness of the alternative understandings of instruments offered by historical studies of technology and medicine therefore provide an important 'freeing up' of creative space, reminding artists of the alternative possibilities written into the history of any technology. In showing the complexity of influences that can shape a device, (exemplified in the thermometer) ANT scholarship is particularly effective at reminding makers that the reification of devices in certain forms are the result of particular theoretical and practical needs specific to particular user communities.

Historians of media and technology have argued that technologies such as the cinema and the telephone remain in a state of flux, only appearing fixed when a large enough system of users and 'protocols' for their use are built around them in order to reinforce and make static (reify) their form. Instead of developing a fixed notion of instruments, an awareness of the historical contexts in which instruments are developed shows that it is possible to consider body sensor instruments as a class of technologies that might mutate, evolve, or regress productively.

Instrumentation and immateriality

The thesis also impacts upon what we might imagine instruments to be interfacing *with*. This observation is particularly important for artists concerned with the phenomenological aspects of human embodiment, who might wish to understand instruments as connecting with human beings without 'objectifying' them. Chapter 1 sets the stage of the discussion by drawing on the work of a number of philosophers who argue in favour of a particular position regarding the ontological status of the 'inner' to the material body. This impacts upon how the physiology of subjects who are being monitored using instruments is understood to relate to their interior state, a theme developed through the thesis discussion of physiology, imagination and poetry, which offer an account of the body as a materially manifest subject (extended materialism). What this does is offer an argument for understanding that instrumental interaction is possible with the 'immaterial' aspects of the subject, by examining how the subjective, imaginative and the poetic, are embodied through physiology.

Particularly central to this is the way in which the thesis develops the theme of the imagination, the thesis argues that aspects of physiology that are accessible to instruments and suggests that it is also possible to consider the *imagination* as present within physiology, as a physiological object or potential. As discussed in chapter 8, the imagination offers a spanning of the material and immaterial. By drawing attention to the role of the imagination as a creative force – the thesis stresses the way in which instruments can be seen as interventions that shape their subjects through their own imposition of certain meanings – particularly palpable in the meaning effect/placebo response. This reading of instruments enables one to understand them as devices that might constitute a method for the creative production of forms of embodied experience. It might be argued that biofeedback artwork, which makes use of real-time physiological data to control or visualise creative representations of body state may offer one conduit for the creation of these kinds of experiences, which in the light of the thesis can be considered to have profound material and visceral effects on the body itself, as well as the experience of the user.

Examples

One research aim of the thesis has been to explore the philosophical implications of investigating the understanding of the possible phenomena accessible by human body sensing instrumentation in settings outside of scientific measurement. In the case of each instrument a poetic history might be reclaimed. These histories offer the opportunity to revisit the time before instruments became reified and to re-imagine those aspects that the imperative for (hard-won) objectivity drove out of them. These examples also serve to fulfill a range of different functions within the thesis, demonstrating different aspects of the effect of the thesis' argument.

Revisiting these instruments through the historical scholarship around them has allowed us recover the symbolic and poetic aspects of their operation. The lie detector, for example, is operated using a placebo effect. The incorporation of the symbolic or meaningful into its protocols for use – mixes the ontology of instrumental machine and the imaginary aspects of the meaning of the technology and context in which it is used. These frighten users into producing certain physiological effects, and the use of questioning and different set-ups (protocols) provide circumstances that allow experimenters to define a difference between familiarity and unfamiliarity, guilt and innocence, knowledge and ignorance. The use of the instrument to detect and evoke these concepts collapses subjective psychology and imagination with the material physiology of body (al la Wittgenstein) allowing us to trick the test if we 'imagine being slapped'.

If the polygraph is not discarded as a pseudoscience, we are left with an interesting performative practice. One might argue that lies do not have any 'objective existence' but as shown in Barad's and Hacking's discussion of phenomena, the way in which experimental set-ups are arranged to cause rather than simply capture particular phenomena – suggests that in the case of human psychology, the lie might well be a artificially created, but no less recordable object – if we are willing to define it in particular instrumental terms – rather than in those of the folk psychology which we might usually associate with the terminology.

The example of the controlled trial first offers an account by which it can be understood how instruments as both material devices and symbolic objects can have an effect upon the body as it is measured: a placebo response, or perhaps more accurately meaning response, to instrumentation enters into the experience and meaning of recording the states of bodies.

By situating the discussion of the controlled trial with the early development of the trial as an instrumental tactic, the thesis supports and develops its understanding of the historical relationship of concepts of the inner and subjective landscape, (in these examples the role is taken by that of the imagination) which show how aspects of the body – such as the imagination, can be specified as part, or not part, of the active medical body. These might be defined in distinction to – or as integral – to the outcomes of medical encounters as observable and active. This has implications for art because it leads us to reconsider the physical impact of imagery, ideas and simulated experiences on the material body, and it is therefore possible to argue, building on the placebo effect, for far more fundamental, material and measurable effects of artistic works to exist than are usually given credit.

The example of the lie detector test extends this discussion one step further by turning this observation on its head and suggesting that knowledge and the imagination might be understood as central to the operation of some devices: the explicit aims of lie detector testing are to measure the knowledge and intentions of a test subject. This type of testing uses a model of the interior of the subject (thus remaining contentious as a form of reliable evidence – and being considered bad science) in order to infer what is, and is not known, and to infer the risk of unforeseen or unpredictable behaviour or hidden motives on the part of the subject. Thus the lie detector test in part interfaces with the imagination and the imagined, causing it to 'matter' in an instrumental sense, if not in the strictly metrological one which medical science has invested in during the last century.

Discussions of instrumental systems like the randomised controlled trial and the placebo effect, and the lie detector test, all therefore stand as examples of the material-discursive formations that might arise, particularly with reference to the separation of the meaningful and symbolic from the realm of instrumental causality by experimental arrangements. These examples show the 'intra-actions' between instruments and bodies.

The automatograph is a historical device that raises certain epistemological concerns regarding the kind of claims that might be attached to the device regarding what the inscriptions that it produces contain. Are they the movements of the imagination? Are they evidence of unconscious urges or knowledge? How might we understand the implications of an unconscious that might be inscribed as a text? The use and construction of devices like the automatograph can serve to articulate questions which link philosophy, psychology and arts practice and demonstrates how potential practices might be constructed around the conception and manufacture of instruments, protocols and ontological claims.

Poetics as a method

Finally, by establishing an analogy with 'poetics', the thesis suggests that applying poetics to instrumentation might serve to stress the creative potential for technology-based practices that represent or shape human experiences. As the poetic use of language produces and reinforces new subjectivities, so does the production of technological and medical products that represent the body.

Poetry appears throughout the thesis. On the one hand it re-links instruments with the flexible meanings that they have been separated from through progressive reification. Take for example the evidence of Castle's historical observation that the thermometer was once, itself, capable of 'feeling', and the flexibility of the language of pulse feeling discussed by Kuriyama.[118] The poetic also serves to link the physiological, instinctive and material body, with the collapse of action, meaning and poetic utterance found in Schleifer's accounts of poetry and Tourette's syndrome.

[118] Both accounts are discussed in chapter 3.

The thesis' final move is to develop a position in relation to Richard Rorty's conception of the poetic as a *method* for understanding, and inspiring, creative interventions in the use of body sensor technology. This synthesis provides an insight into the way in which a methodology from the arts might be seen to afford an alternative approach to understanding the development of technologies. While the scholarship that the thesis draws upon in order to observe what is problematic about, or potentially overlooked in the field of body instrumentation is from history, philosophy and medicine, the key to understanding how these observations might be acted up, stems from the way in which artists and poets have traditionally approached the world; they are always exploring what it affords as a medium for creative practices, in particular for the creation of experience. While the thesis, paradoxically, serves to justify the methods of the artistic disciplines to themselves, by drawing on scholarship that confirms constructedness and imaginative potential, it also argues that the methods of the arts can be seen as instrumentally valid and in fact, may offer a way to importantly, avoid deterministic approaches to the construction of human experience through technologies.

Summary

This thesis began with a preface that discussed the beginnings of my research project, and the ideas and questions that had been foremost in my mind when I began making computer based artworks that visualised or were controlled by biosignals. There are a few points in the thesis that really summarise the transformation that has taken place in how I understand this activity; the lie detector as an instrument that operates through a performance, Daniel Moerman's tears at a movie and smiles at a puppy, and finally, the imaginary physiology of being slapped.

What this research has made clear is that if creative practitioners are to make use of the potential of instruments it is imperative to remember that using these devices, like any form of representation, results in the constructive shaping of living entities. Instruments do not just give access to what is 'out there', but invite us to explore and invent alternate bodies. Rather than accept the devices that have been developed for other practices such as medicine or physiological science intact with predefined meanings of heat, breath, thought left intact, the thesis suggests, and assembles the materials to aid in an unpicking of what we understand by instrumentation, at the level of the ontology of the device, not at that of the representation that it creates. Just as the body is an instrument for the inner, 'suffused with meaning, thought, passion and will', our environments and technologies may also be thought of as intimately connected and expressive of knowledge, symbol and meaning. This is an opportunity that should no be overlooked by those of use working creatively, rather than scientifically, with these technologies.

Further work

There are numerous avenues that offer future paths for the ongoing exploration of the topics of this thesis, as well as many aspects of the discussion that were not incorporated or extended as much as they could have been because of the limitations of time and space. In addition to this the prospect of applying the ideas and understanding of instrumentation developed in the thesis, as well as experimental projects with device like the automatograph, now increasingly – and with completion of this document, contribute to the continuation (transformed) of the author's own arts practice described in the preface.

One research direction is to continue investigations of instrumental work in early psychophysiology, the experiments of investigators such as Wundt, Fechner, and Munsterberg, who all made instrumental investigations of perceptual experience. Fechner in particular proposed a certain philosophical perspective that might have been included in the early parts of the thesis. Investigations of spiritualism are also invoked in chapter 6, in the discussion of the placebo effect, this is a rich area of scholarship and the arguments made by the thesis regarding the imagination and its effects on the body might fruitfully be extended into this realm.

Further work on the understanding of instrumental action, particularly as it links to the meaning effect also appears promising, as suggested by some preliminary investigations of the work of Peter Winch (Winch, 1958; Lerner &

Winch, 2002) and his discussions of magic and instrumental action in the context of anthropology, which promises much of interest as a route for further extension of the thesis' discussions of how instruments might be seen as symbolic but also instrumental, and the links between language and instruments.

Bibliography

Abrahams, M. H. (ed.), (2000) *The Norton Anthology of English Literature*, New York and London: W.W. Norton & Company.

Almerud, S., Alapack, R. J., Fridlund, B., & Ekeburgh, M., (2008), 'Beleaguered by Technology: Care in Technologically Intense Environments'. *Nursing Philosophy*, 9, p.55-61.

Andreassi, J. L., (2006) *Psychophysiology: Human Behaviour and Physiological Response*, London: Routledge.

Bachelard, G., (1984) *The New Scientific Spirit*, Translated by Goldhammer, A., Boston: Beacon Pr.

Bacon, F., (1900) *Advancement of Learning and the Novum Organon*, New York: Willey Book Co.

Barad, K., (1999) 'Agential Realism; Feminist Interventions in Understanding Scientific Practices', *in* Biagioli, M., *The Science Studies Reader*, London: Routledge.

Barad, K., (2003) 'Posthumanist Performativity: Toward an Understanding of how Matter comes to Matter', *Signs*, 28. No. 3, pp. 801-831.

Barad, K., (2007) *Meeting the Universe Halfway*, Durham & London: Duke University Press.

Benjamin, L., (2007) *A Brief History of Modern Psychology*, Malden MA, Oxford, Victoria: Blackwell.

Benovoy, M., Cooperstock, J., Deitcher, J., (2008) 'Biosignals Analysis and its Application in a Performance Setting - Towards the Development of an Emotional-Imaging Generator', *Proceedings of Biosignals 1*, pp.253-258.

Benovoy, M. et al., (2007) 'Audiovisual Content Generation Controlled by Physiological Signals for Clinical and Artistic Applications', *Proceedings of the 3rd Summer Workshop on Multimodal Interfaces (eNTERFACE07)*, Istanbul, Turkey.

Blackburn, S., (1994) *Oxford Dictionary of Philosophy*, Oxford: Oxford University Press.

Blackwell, B., Bloomfield, S. S., Buncher, C. R., (1972) 'Demonstration to Medical Students of Placebo Responses and Non-drug Factors', *Lancet.* 10 ; no 1, pp.1279-82.

Milton, A. S., 'Thermal Physiology: Brief History and Perspectives' *in* Blatteis, C.M., *Physiology and pathophysiology of temperature regulation*, London: World Scientific.

Bijker, W.E., Hughes, T.P. and Pinch, T.J., (1987) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Cambridge Mass.: MIT Press.

Bollet, A.J., (2004) *Plagues and Poxes: the Impact of Human History on Epidemic Disease*, New York: Demos Medical Publishing.

Breidert, M., and Hofbauer, K., (2009) 'Placebo: Misunderstandings and Prejudices', *Deutsches Ärzteblatt International*, 106 (46), pp.751-755.

Brouse, A., 'A Young Person's Guide to Brainwave Music', *Horizonzero.* Available at: http://www. horizonzero.ca. [Accessed 11 June, 2010].

Bunn, G., (2007) 'Spectacular Science: The Lie Detector's Ambivalent Powers', *History of Psychology*, 10 (2), pp.156-178.

Butler, J., (1990) *Gender Trouble: Feminism and the Subversion of Identity*, London: Routledge.

Butler, J., (1993) *Bodies That Matter: On the Discursive Limits of 'Sex'*, New York: Routledge.

Button, G., (1991) *Ethnomethodology and the Human Sciences*, Cambridge: Cambridge University Press.

Boon, M., (2009) 'Instruments in Science and Technology', *in* Olsen, J. K., B., Pedersen, S. A., and Hendricks, V. F. (Eds.), *A Companion to the Philosophy of Technology*, Chichester: Blackwell.

Braun, M., (1994) *Picturing Time: The Work of Etienne-Jules Marey (1830-1904)*, Chicago: University of Chicago Press.

Brockliss, L. W. B., (1978) 'Medical Teaching at the University of Paris, 1600-1720'. *Annals of Science* 35 (3), pp.221-251.

Brugger, P., (1999) 'One Hundred Years of an Ambiguous Figure: Happy Birthday, Duck/Rabbit', *Perceptual and Motor Skills*, 89 (3), pp.973-977.

Cacioppo, J.T., Tassinary, L.G., and Berntson, G.G., (2007) *Handbook of Psychophysiology*, Cambridge: Cambridge University Press.

Canguilhem, G., (1989) *The Normal and the Pathological*, New York: Zone.

Castle, T., (1995) *The Female Thermometer; Eighteenth Century Culture and the Invention of the Uncanny*, Oxford: Oxford University Press.

Cattell, J., (1928) 'Early Psychological Laboratories'. *Classics in the History of Psychology -- Cattell (1928)*. Available at: http://psychclassics.yorku.ca/Cattell/earlylabs.htm [Accessed January 5, 2011].

Churchland, P. M., (1981) Eliminative Materialism and the Propositional Attitudes, *Journal of Philosophy*, 78, pp.67-90.

de Craen, Anton, J. M., Pieter, J., Roos, A., de Vries, L., and Kleijnen, J., (1996) 'Effect of Colour of Drugs: Systematic Review of Perceived Effect of Drugs and of their Effectiveness.' *British Medical Journal*. 313 (7072) pp.1624-1626.

de Craen, A. J. M., et al. (1999) 'Placebos and Placebo Effects in Medicine: Historical Overview'. *Journal of the Royal Society of Medicine* 92, pp.511-515.

Cooper, C.L. and Dewe, P., (2004) *Stress: A Brief History*, Oxford: Wiley-Blackwell.

Dagognet, F., (1992) *Etienne-Jules Marey: A Passion for the Trace*, New York: Zone.

Daston, L., (1978) 'British Responses to Psycho-Physiology', 1860-1900, *Isis*, 69: 192-208.

Daston, L. (1992) 'Objectivity and the Escape from Perspective', *Social Studies of Science*, 22: 597-618.

Daston, L. (2002-2003) 'Scientific Error and the Ethos of Belief', *Research Report 2002-2003*. Berlin: Max Planck Institute for the History of Science.

Daston, L. & Galison, P., (2007) *Objectivity*, New York: Zone.

Davis, A.B., (1981) *Medicine and its Technology: an Introduction to the History of Medical Instrumentation*, Westport, Connecticut: Greenwood Press.

DeLanda, M., (2005) *Intensive Science and Virtual Philosophy*, London: Continuum.

Dennett, D.C., (2004) *Freedom Evolves*, New Ed., London: Penguin.

Descartes, R., (2008 [1641]) *Meditations on First Philosophy: with Selections from the Objections and Replies*, Oxford: Oxford University Press.

Dumit, J., (2004) *Picturing Personhood; Brain Scans and Biomedical Identity*, Princeton and Oxford: Princeton University Press.

Duffin, J., (2005) *Lovers and Livers; Disease Concepts in History*, Toronto, Buffalo, London: University of Toronto Press.

Drayson, H., (2007) 'Gestalt Biometrics', *Proceedings of MutaMorphosis: Challenging Arts and Sciences.* Available at: http://mutamorphosis.wordpress.com/2009/02/21/gestalt-biometrics/ [Accessed February 15, 2011].

Drayson, H., (2009) 'Constructed Bodies; Can Biomedical Instruments Become Tools of Self-perception?' In *New Realities, Being Syncretic,* Ascott et al. (eds), Wein and New York: Springer.

Fischer, C. S., (1994) *America Calling: A Social History of the Telephone to 1940.* Berkely and Los Angeles: University of California Press.

Flusser, V. (2000) *Towards a Philosophy of Photography,* London: Reaktion.

Forbes, J., (1846) Homoeopathy, Allopathy and "Young Physic", *British and Foreign Medical Review*, pp.225-265.

Foucault, M., (2003 [1973]) *The Birth of the Clinic,* London: Routledge.

Franklin, B., et al. (1837) *Animal Magnetism: Report of Dr. Franklin and Other Commissioners, Charged by the King of France with the Examination of the Animal Magnetism as Practised at Paris,* H. Perkins.

Frenkel, O., (2008) 'A Phenomenology of the 'Placebo Effect': Taking Meaning from the Mind to the Body'. *Journal of Medicine and Philosophy*, 33 (1), pp.58-79.

Gallagher, S., (2006). *How the Body Shapes the Mind,* Oxford: Clarenden Press.

Gaukroger, S., (2001) *Francis Bacon and the Transformation of Early-Modern*

Philosophy, Cambridge: Cambridge University Press.

Good, B. J., (1994) *Medicine, Rationality and Experience: An Anthropological Perspective*, Cambridge: Cambridge University Press.

Gooday, G., (2000) 'Instruments as Embodied Theory', pp.376-8, *in* Hessenbruch, A. (ed.), *Reader's Guide to the History of Science*, London: Taylor and Francis.

Granich, R. M., et al. (2009) 'Universal Voluntary HIV Testing with Immediate Antiretroviral Therapy as a Strategy for Elimination of HIV Transmission: A Mathematical Model.' *The Lancet* 373 (9657), pp.48-57.

Garnett, G. P., and Baggaley, R. F., (2009) 'Treating Our Way Out of the HIV Pandemic: could we, would we, should we?' *The Lancet* 373, (9657), pp.9-11.

Grayling, A.C., (2005) *Descartes ; The Life and Times of a Genius*, New York: Walker and Company.

Gregory, R., (ed.), (1987) *Oxford Companion to the Mind.* Oxford: Oxford University Press.

Grosz, E., (1994) *Volatile Bodies; Towards a Corporeal Feminism*, Bloomington and Indianapolis, Indiana University Press.

Hacker, P.M.S., (2007) *Wittgenstein; on Human Nature*, London: Phoenix.

Hacking, I., (1983) *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*, Cambridge: Cambridge University Press.

Hacking, I., (1992) 'The Self-Vindication of the Laboratory Sciences', *in Science as Practice and Culture.* Pickering, A., (ed.), Chicago and London: University of Chicago Press.

Hankins, T. L. and Silverman, R. J., (1995) *Instruments and the Imagination*, Princeton: Princeton University Press.

Hansen, B., (1992) 'American Physicians' "Discovery" of Homosexuals, 1880-1900: A New Diagnosis in a Changing Society', *in* Rosenberg, C. E., Golden, J. L. (eds.) *Framing Disease: Studies in Cultural History*, Piscataway: Rutgers University Press (p.104-133).

Haraway, D.J., (1991) *Simians, Cyborgs, and Women: the Reinvention of Nature*, New York: Routledge.

Harman, G., (2008) *The Assemblage Theory of Society*, [online] The Assemblage Theory of Society « ANTHEM. Available at: http://anthem-group.net/2009/01/05/the-assemblage-theory-of-society/ [Accessed February 15, 2011].

Harman, G., (2009) *Prince of Networks: Bruno Latour and Metaphysics*, re.press.

Harris, J., (2005) 'The Ordering of Things: Organization in Bruno Latour', *The Sociological Review*, 53, pp.163-177.

Harrison, M., (2004) *Disease and the Modern World: 1500 to the Present Day*, Oxford: Wiley-Blackwell.

Hayles, N. K., (1993) 'Virtual Bodies and Flickering Signifiers'. *October*, 66, pp.69-91.

Haygarth, J., (1800) *Of the Imagination, as a Cause and as a Cure of Disorders of the Body; Exemplified by Fictitious Tractors, and Epidemical Convulsions (New Edition, with Additional Remarks)*. Bath ; R. Crutwell.

Heidelberger, M., (2004) *Nature from Within: Gustav Theodor Fechner and his Psychophysical Worldview*, Pittsburgh: University of Pittsburgh Press.

Herr, H.W., (2005) 'Franklin, Lavoisier, and Mesmer: Origin of the Controlled Clinical Trial'. *Urologic Oncology*, 23(5), 346-351.

Hrobjartsson, A., and Gotzsche, P. C., (2001) 'Is the Placebo Powerless?— An Analysis of Clinical Trials Comparing Placebo with No Treatment'. *The New England Journal of Medicine* 344, pp.1594-1602.

Ihde, D., 1979. *Technics and Praxis*, Dordrecht: D. Reidel.

Ihde, D., 1991. *Instrumental Realism: the Interface Between Philosophy of Science and Philosophy of Technology*, Bloomington: Indiana University Press.

Illich, I., (1975) *Medical Nemesis*, London: Marion Boyars.

James, S., (1999) *Passion and Action; the Emotions in Seventeenth-century Philosophy*, Oxford: Oxford University Press.

Jastrow, J., (1892) 'Involuntary Movements', *Popular Science Monthly, April 1892*, pp.743-750.

Johnston, P., (1993). *Wittgenstein: Rethinking the Inner*, London: Routledge.

Joyce, K.A., (2009) *Magnetic Appeal: MRI and the Myth of Transparency*, New York: Cornell University Press.

Kaptchuck, T. J., (1998) 'Powerful Placebo: the Dark Side of the Randomised Controlled Trial'. *The Lancet*, 351, pp.1722-25.

Kerr, C.E., Milne, I., and Kaptchuk, T. J., (2007) *William Cullen and a Missing Mind-body Link in the Early History of Placebos*, The James Lind Library. Available at: http://www.jameslindlibrary.org [Accessed 24 February, 2009].

Khut, G., (2006) *Development and Evaluation of Participant-Centred Biofeedback Artworks*. Unpublished doctoral exegesis, University of Western Sydney.

Kihlstrom, J. F., (2010) *Joseph Jastrow and His Duck -- Or Is It a Rabbit?* Jastrow Duck Rabbit. Available at: http://socrates.berkeley.edu/~kihlstrm/JastrowDuck.htm [Accessed December 20, 2010].

Kristeva, J., (1982) *Powers of Horror: An Assay on Objection*, New York: Columbia University Press.

Knapp, B. and Lusted, H. (1990) 'A Bioelectric Controller for Computer Music Applications,' *Computer Music Journal*, 14 (1), pp.42-47.

Kuhn, T.S., (1970) *The Structure of Scientific Revolutions*, 2nd ed., Chicago: University of Chicago Press.

Kuriyama, S., (1999) *The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine*, New York: Zone.

Latour, B., and Woolgar, S., (1979) *Laboratory Life; The Social Construction of Scientific Facts*, Beverly Hills, London: Sage.

Latour, B., (1987) *Science in Action*, Milton Keynes: Open University Press.

Latour, B., (1993a [1988]) *The Pasteurization of France*, Cambridge Mass.: Harvard University Press.

Latour, B., (1993b) *We Have Never Been Modern*, Cambridge Mass.: Harvard University Press.

Latour, B., (1999) On Recalling ANT, *in* Law, J. and Hussard, J., *Actor Network Theory and After,* Oxford: Blackwell.

Latour, B., (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory,* Oxford: Oxford University Press.

Lerner, B.D., & Winch, P., (2002) *Rules, Magic, and Instrumental Reason: A Critical Interpretation of Peter Winch's Philosophy of the Social Sciences,* London: Routledge.

Levenson, R. W., (1992) 'Autonomic Nervous Systems Differences Among Emotions', *Psychological Science,* 3, no.1, pp.23-27.

Lewis, T., (1920) *The Mechanism and Graphic Registration of the Heart Beat,* London, Shaw & Sons.

Lusted, H. and Knapp, B., (1988) 'Biomuse: Musical Performance Generated by Human Bioelectric Signals', *Journal of the Acoustic Society of America,* 84, Issue S1, pp.179-179 (November 1988).

Lewis, T. (1920) *The Mechanism and Graphic Registration of the Heart Beat,* London, Shaw & Sons.

Lind, J., (1753). *A Treatise of the Scurvy. In Three Parts: Containing an inquiry into the Nature, Causes and Cure, of that Disease. Together with a Critical and Chronological view of what has been Publicised on the Subject.* Edinburgh, Printed by Sands, Murray and Cochran for A. Kincaid and A. Donaldson.

Lock, M., (1993) *Encounters with Aging: Mythologies of Menopause in Japan and North America.* Berkley and Los Angeles: University of California Press.

Long, G.M. & Toppino, T.C., (2004). Enduring Interest in Perceptual Ambiguity: Alternating Views of Reversible Figures. *Psychological Bulletin,* 130(5), 748-768.

Lynch, J. J. (1979). *The Broken Heart: The Medical Consequences of Loneliness.* New York: Basic Books Inc.

Lynch, J. J., (1999) 'Human Contact in Life-Threatening Environments', *in* Samson, C. (Ed.) *Health Studies: A Critical and Cross-Cultural Reader,* Oxford: Blackwell.

McCauley, R.N. & Bechtel, W., (2001) 'Explanatory Pluralism and Heuristic Identity Theory'. *Theory and Psychology,* 11(6), 736 -760.

Miller, F. G. and Rosenstein, D. L., (2006) 'The Nature and Power of the Placebo Effect'. *Journal of Clinical Epidemiology* 59, pp.331-335.

Mitchell, S. W., (1892) *The Early History of Instrumental Precision in Medicine; An Address Before the Second Congress of American Physicians and Surgeons,* New Haven: Tuttle Morehouse and Taylor.

Miranda, E. & Brouse, A., (2005) 'Toward Direct Brain-computer Musical Interfaces', *in Proceedings of the 2005 conference on New Interfaces for Musical Expression,* Vancouver, Canada: National University of Singapore, pp.216-219.

Moerman, D. J., (2002) *Meaning, Medicine and the Placebo Effect.* Cambridge: Cambridge University Press.

Mol, A., (2002) *The Body Multiple,* Durham and London: Duke University Press.

Moore, G., (1852). *The Power of the Soul Over the Body; Considered in Relation to Health and Morals,* New York: Harper and Brothers.

Moore, W., (2005) *The Knife Man; The Extraordinary Life and Times of John Hunter, Father of Modern Surgery,* New York: Broadway Books.

Moore, W., (2009) *John Hunter: Learning from Natural Experiments, 'Placebos', and the State of Mind of a Patient in the 18th Century,* The James Lind Library. http://www.jameslindlibrary.org. [Accessed Monday 6 April 2009].

Nagel, T., (1986) *The View from Nowhere,* Oxford: Oxford University Press.

Nye, D.E., (2006) *Technology Matters: Questions to Live With,* Cambridge Mass.: MIT Press.

Pettit, M., (2007) 'Joseph Jastrow, the Psychology of Deception, and the Racial Economy of Observation', *Journal of the History of Behavioral Sciences,* 43, pp.159-175.

Picard, R.W., Vyzas, E. and Healey, J., (2001) 'Toward Machine Emotional Intelligence: Analysis of Affective Physiological State', *IEEE transactions pattern analysis and machine intelligence,* 23 (10).

Pickering, A., (1992) *Science as Practice and Culture,* Chicago: University of Chicago Press.

Pickering, A., (1995) *The Mangle of Practice: Time, Agency, and Science,* Chicago: University of Chicago Press.

Ploeg, I., (2003) Biometrics and the Body as Information: Normative Issues of the Socio-technical Coding of the Body, *in* Lyon, D., (ed.) *Surveillance as Social Sorting; Privacy, Risk and Digital Discrimination.* London and New York: Routledge.

Porter, R., (1997) *The Greatest Benefit to Mankind: A Medical History of Humanity*, London: Harper Collins.

Porter, T. M., (1996) *Trust in Numbers*, Princetown: Princeton University Press.

Postel-Vinay, N., (ed.) (1996) *A Century of Arterial Hypertension, 1896-1996*, London: John Wiley & Sons.

Punt, M., (2000) *Early Cinema and the Technological Imaginary*, Amsterdam: Postdigital Press.

Rasor, E.L., (2004) *English/British Naval History to 1815: A Guide to the Literature*, Westport, Connecticut: Greenwood Press.

Reiser, S. J., (1978) *Medicine and the Reign of Technology*, Cambridge, Cambridge University Press.

Reiser, S. J., (1993) Technology and the Use of the Senses in Twentieth-Century Medicine, *in* Bynum, W. F., and Porter, R. (eds.), *Medicine and the Five Senses*, Cambridge, Cambridge University Press.

Rorty, R. (1980) *Philosophy and the Mirror of Nature*, Oxford: Basil Blackwell.

Rorty, R., (1989) *Contingency, Irony, and Solidarity*, Cambridge: Cambridge University Press.

Rorty, R., Engel, P., and Savidan, P., (2007) *What's the Use of Truth?* New York: Columbia University Press.

Rose, N.S., (2007) *The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the Twenty-First Century*, Princeton: Princeton University Press.

Rosenboom, D., (1976) *Biofeedback and the Arts: Results of Early Experiments*, Vancouver: A.R.C Publications.

Rosenboom, D., (1997) *Extended Musical Interface with the Human Nervous System: Assessment and Prospectus: Leonardo Monograph Number 1*, Revised Edition, San Francisco: International Society for the Arts, Sciences and Technology.

Samson, C., (1999) 'Biomedicine and the Body', *in* Samson, C. (ed.) *Health Studies: A Critical and Cross Cultural Reader*, Oxford: Blackwell.

Schleifer, R., (2009) *Intangible Materialism: The Body, Scientific Knowledge, and the Power of Language*, Minneapolis: University of Minnesota Press.

Schroeder, W. R., (1998) 'Continental Philosophy', *in* Critchley, S. and Schroeder, W.R., *A Companion to Continental Philosophy: New edition*, Oxford: Wiley-Blackwell.

Schwartz, M.S., (1998) *Biofeedback: A Practitioner's Guide: Second Edition*, New York: Guilford Press.

Smythies, J., (2009) 'Brain and Consciousness: The Ghost in the Machines', *Journal of Scientific Exploration*, 23, No. 1, pp. 37–50, 2009.

Saunders, B., (2008) *CT Suite: The Work of Diagnosis in the Age of Noninvasive Cutting*, Durham & London: Duke University Press.

Sha. R. C., (2009) 'Toward a Physiology of the Romantic Imagination.' *Configurations* 17.3, pp.197-226.

Shapin, S., (1988) 'The House of Experiment in Seventeenth-Century England', *Isis*, 79, pp.373–404.

Shapin, S. (2000) Descartes the Doctor: Rationalism and its Therapies. *British Journal for the History of Science*, 33; pp.131-154.

Shapin, S., (2010) *Never Pure: Historical Studies of Science as If It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority*, JHU Press.

Sibum, H. O., (1995) 'Reworking the Mechanical Value of Heat: Instruments of Precision and Gestures of Accuracy in Early Victorian England', *Studies in the History of Philosophy of Science..* Vol. 26, no. 1. pp. 73-106, 1995.

Singleton, V., (2008) 'Stabilizing Instabilities: The Laboratory in the UK Cervical Screening Program;, *in* Berg, M. and Mol, A. (eds.), *Differences in Medicine: Unravelling Practices, Techniques, and Bodies*, Durham & London: Duke University Press.

Slade, P., (1997) 'Iatrogenesis', *in* Baum, A. *Cambridge handbook of psychology, health, and medicine*, Cambridge: Cambridge University Press, pp.507-509.

Spiegel, D., (2004) 'Placebos in Practice', *British Medical Journal*, 329, pp.927-928.

Steptoe, A., (2007) 'Psychophysiological Contributions to Behavioural Medicine and Psychosomatics', *in* Cacioppo et al. *Handbook of Psychophysiology: Third Edition.* Cambridge: Cambridge University Press.

Stoljar, D., *Physicalism.* Available at: http://plato.stanford.edu/entries/physicalism/ [Accessed February 15, 2011].

Sprat, T. (1667) *The History of the Royal Society of London for the Improving of Natural Knowledge*, London: Royal Society.

Tilburt, J. C., et al., (2008) 'Prescribing "Placebo Treatments": Results of National Survey of US Internists and Rheumatologists', *British Medical Journal*; 337, 1938.

Veerbeck, P-P., (2005) *What Things Do; Philosophical Reflections on Technology, Agency and Design*, Pennsylvania: Penn. State University Press.

Wittgenstein, L., (1997 [1958]) *Philosophical Investigations*, 2nd ed., Oxford: Blackwell.

Winch, P., (1958) *The Idea of a Social Science and its Relation to Philosophy*, London: Routledge.

Winner, L., (1999) 'Do Artifacts Have Politics?' *In* MacKenzie, D. & Wajcman, J. (Eds.) *The Social Shaping of Technology*, Second ed. Buckingham: Open University Press.

Murdoch, D., (2001) 'Bohr' *in* Newton-Smith, W.H.,. (ed) *A Companion to the Philosophy of Science*, Oxford: Wiley-Blackwell, pp.26-30.

Zics, B., (2008) *Transparency, Cognition and Interactivity: Toward a New Aesthetic for Media Art.* PhD Thesis. Newport, Wales: University of Wales.

Appendix 1. Constructed Bodies; How can physiological instruments become tools of self perception?

Constructed Bodies; How can physiological instruments become tools of self perception?

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Abstract

> The invalidity of the sick man's judgement concerning the reality of his own illness is an important theme in a recent history of disease. [...] "Health," says Leriche, "is life lived in the silence of the organs"... The state of health is one in which the subject and his body are one. Conversely, the awareness of the body consists in a feeling of limits, threats, obstacles to health.
> Georges Canguilhem, (1981, p.91)

Rene Leriche's phenomenally based image of health serves to frame a concern regarding the integration of physiological sensor technologies into the consumer market. However, this analysis is not so concerned with the body in a state of illness, when normal life is interrupted, but at the point when physiological instrumentation is diffused into what Don Ihde refers to as the 'technological texture' (Ihde:1979) of our day to day environment. It is this possibility that demands an enquiry into what may happen when instrumentation gives the body a voice.

Introduction; what happens when the organs break their silence?

Currently physiological sensors are found mainly where the normal limits of the human body are tested or compromised: space or deep sea exploration, military, sports and medicine. However, there is an ever growing market in the western world for home consumer medical technologies, and here, the usual forces which appear to drive the diffusion of computer based technologies into consumer markets appear to be at work: miniaturization, falling costs, increase in processor power. These factors, in addition to the adoption of paradigms such as ubiquitous, affective and physiological computing, appear to justify the very common expectation that there will be an increasing prevalence of these instruments in everyday life. In addition to the medical applications of these devices such as wearable heart, blood glucose, galvanic skin response monitors; there are also applications in the entertainment sectors as game controllers, emotion or brainwave responsive entertainment systems as well as sports and wellness applications.

This paper is not concerned however, with specific technological products, but instead aims to consider the general effects of an integration of physiological sensors into the 'technological atmosphere'. What effects will objective, medically significant information about the body have upon subjective perception of embodiment? How can we consider its integration into perception? Adopting a theme from Canguilem's reading of Leriche it is hoped that we may explore a question which, while accompanied by much expectation, is surrounded with uncertainty.

Incorporating technological information into the phenomenal world; how will organs speak?

Let us first turn to the question of how physiological instruments might allow organs to 'speak'. The Philosophy of Technology provides some structures describing how technological data is incorporated into the phenomenal world. I will first comment upon the phenomenological method as it relates to our study and some of the attempts to characterize human-machine interaction.

Ihde's analysis adopts Merleau-Ponty's 'perceiving body-subject' – the human as an active perceiver. This definition of the technology user is a constructive model, as it makes possible a unitary rather than reductive analysis of the subject's interaction with physiological data. It also follows Canguilhem's analysis, defining illness as a state experienced by the 'sick man'(1989, p.90) rather than through physiological or medical definition.

Some thinkers from the lineage of Phenomenology have considered technology as a negative force within the domain of lived experience, or 'lifeworld'. Following Heidegger's assertion that technology treats everything in the world as a 'standing reserve' - basically a raw material to be used up, writers like Winner (1977) view technological activity as one of constant colonization, 'technology goes where it has not yet been'. Albert Borgmann's thought takes a particularly dystopian position when reviewing the effects of modern technology on the lifeworld. Using a 'device paradigm' - examining individual devices modifications upon human experience; Borgmann's work characterizes technology as 'disemburdening', in that it creates devices that are a means to an end, removing active input from their user. He argues that as technology becomes invisible, technological devices 'alienate' their uses from the lifeworld and its focal practices (Veerbeck, 2002).

Applying 'disemburdenment' to physiological sensing might suggest that technological access to bodily information might supercede or interfere with somatic perception, resulting in a diminished reliance upon inherent sensory capacities. However, psychological studies have suggested that this is not the case, diabetic patients who use blood glucose monitors to regulate their food and insulin intake have been found to still 'rely on symptoms' and that 'subjective cues win out over the procedures guided by abstract knowledge'. This shows that in day to day use, somatic information takes precedence over objective, instrumentally derived information about the body (Baum et al:2001, p.23). However, this precedence of one modality of information over another - somatic over instrumental - may be attributable to features of the interface.

Ihde clarifies this interface difference with an analysis which takes a more specific approach to the incorporation of technology into phenomenal experience. In his earlier work he makes a distinction between *hermeneutic* and *embodied* relations with technology(Ihde, 1979). *Hermeneutic relations* are textual, semantic interactions. Here, as in the earlier example of blood-glucose monitors, information from the device is assimilated through cognitive engagement. As in the common conception of scientific instruments as producers of dials and graphs, technological devices that fit this category are *read* by the user.
In contrast *embodiment relations* are the product of the incorporation of a technology into the activity of living. Heidegger's famous example of his father's hammer typifies this, where the tool is treated more like an extension of the user's body. The difference between these two forms of interaction allows the speculation that physiological devices which have the correct *interfaces* may integrate into somatic perceptions.

In fact, this integration may be a two way process. Commenting on a number of technological projects utilizing prosthetic, brain-computer and haptic feedback for rehabilitation and sensory enhancement, Andy Clark argues that the neural plasticity of the brain demonstrated by the success of these experiments shows how non-biologically derived sensor data is easily incorporated into active bodily schema. He points out that "The key to effective sensory substitution is goal-driven motor engagement" (2000, p.269), which allows the user's brain to test the boundaries and significance of the incoming data and their interaction with it. Initially, this appears not to apply to physiological processes which we might consider non motor-driven, but in fact the paradigm of biofeedback therapy has successfully demonstrated that physiological instruments can help users learn to actively and intentionally modify their own physiological functions.

Ihde also delimits the contents of perception of the body, according to the information sources that influence it. He refers to what we might consider the authentic or directly perceived body as ***Body One.*** In contrast ***Body Two*** is comprised of cognitive information, such as cultural and social knowledge and judgments, memory and expectation (Ihde, 2002). It is possible to shoehorn our definitions of embodiment relations into bodies one and two, Body One is where we might find the direct perception of embodiment relations, whereas Body Two would be the arena in which hermeutic relations took place and modified self perception based on cognitive data. The fact that this seems so messy a tactic is that our perceiving body-subject resists this division. The apparently ***direct perception*** of Body One is contested as it incorporates unmediated sensory data.

This problem comes about because what we might imagine are distinct mental contents, such as abstract knowledge or somatic cues, are incorporated within perception. We can see this clearly in Wittgenstein's Duck/Rabbit illustration and other visual illusions which defy visual categorization or shift between different perceptual interpretations. These examples demonstrate that abstract knowledge influences how perceptual cues are interpreted at the moment of perception. Therefore as far as a delimitation of phenomenological embodied experience, Body One and Body Two can be useful to categorize incoming information, but not to prioritize its effects or even to separate them within subjective experience.

Assigning meaning to somatic information; significance and symptoms.

Whether the organs have anything to say is dependent upon who is listening. Leriche draws a distinction between illness from the perspective of the doctor and that of the patient; "The idea must be accepted that the disease of the sick man is not the anatomical disease of the doctor. A stone in the atrophic gall bladder can fail to give symptoms for years and consequently create no disease, although there is a state of pathological anatomy... The difficulty must no longer be conjured away by simply saying that there are silent and masked form of disease: these are nothing but mere words." (1981, p.94).

As we see, the physician's definition of pathology is situated on a different part of the continuum of physiological normality to that of the experiencing man. The instrumentation of medical practice; both as a knowledge system, and a set of technologies which render visible the functions of the body, allow the physiologist to discover functional irregularities which have not yet, or may not ever, manifest themselves as the phenomenal experience of illness. These deviations from the norm are recognised "because today's practitioners are the heirs to a medical culture" which allows them to recognise the possible outcome of certain symptoms or abnormalities based upon historical knowledge and the fact that "at one time this experience gave rise to, summoned up, that knowledge" (ibid, p.95).

In a study similar to that of the diabetes patients above, patients being treated for hypertension (physiologically classed as high blood pressure but not severe enough that it produces any symptoms) found 80% of patients reporting that "a variety of somatic cues such as heart palpitations, warm face, and headache" allowed them to tell if they had elevated blood pressure, even when they were aware that the disorder was asymptomatic. It appears therefore, that the condition of diagnosis leads patients to assign symptomatic significance to observed bodily events.

The field of health psychology acknowledges the complications presented by the mixing of information and experience Body One and Body Two within perception. As a discipline Heath Psychology considers that "much of the decoding process takes place outside awareness" (Baum et al:2001, p.26) during the interpretation of somatic experience into symptoms. Research here makes a further division of somatic experiences similar to Ihde's which can assist in an analysis of how health significant information is dealt with by patients, and makes a distinction between somatic sensations which have reference to patients' past illness experiences and somatic memory, and those which do not.

Baum et al. (2001) explain that;

"The knowledge base used to transform a somatic sensation into a symptom includes both semantic memories (e.g., memories of labels such as heart disease, cancer, and colds) and concrete, perceptual memories of personal somatic experiences (e.g., memory of painful sensations in specific parts of the body during specific illness episodes)".

Whilst cognitive and abstract strategies for illness management are elicited by patients semantic knowledge of medical schema, "Perceptual memories of specific episodes... appear to generate an immediate, sensory link to appraisals of health status and treatment efficacy..." In addition to this, somatic cues which access memory "play a central role in the elicitation and maintenance of emotional reactions". (2001, p.23).

This memory based somatic response can be linked to Clark's discussion of how technologies become integrated into active bodily schema through a process of motor engagement. Learned responses to bodily sensations linked to illness may operate in a similar fashion, allowing physiological sensor technologies with embodied interfaces to generate "immediate, sensory link(s)" which will influence emotional reactions and appraisals of health status in their users.

Conclusion

There are a number of implications proceeding from the ideas we have tested to define phenomenal interactions - interactions with technology and with health significant somatic experiences. Physiological instrumentation allows the detection of medically defined abnormalities which are not accessible to normal perception. In everyday use however, there is a possibility that medical instruments may diffuse physician's definitions of illness, and with them, the broader possibility of pathology, into phenomenal experiences of somatic events. Research with patients who are currently using technologies of these types suggests that embodied somatic information have far more affective power over users, which may also result in stress responses to information which is diagnostically loaded from a medical perspective, but may never result in illness.

However these technologies represent a potential interface of the user to somatic information that may be able bypass semantic medical schema and definitions through embodied interfaces. We can suppose that this will result in more affective and instinctive responses to objective body information from instruments. An effect such as this may allow patients to engage more easily in their own health management, for example to use medications correctly - as in the case of the diabetics discussed earlier.

While this is only the opening of a conversation about the effects of these devices, we have seen how organs might speak through technologies, and begun to understand from a phenomenological standpoint how they might be interpreted.

Bibliography

Baum, A., Reventson, T., A. & Singer, J., E., 2001. *Handbook of Health Psychology,* Lawrence Erlbaum Associates.

Cacippo, J. T., Tassinary, L. G. & Berntson, G. G., 2000. *Handbook of Psychophysiology,* Cambridge, Cambridge University Press.

Canguilhem, G., 1991. *The Normal and the Pathological,* New York, Zone Books.

Clark, A., 2007. Re-Inventing Ourselves: The Plasticity of Embodiment, Sensing, and Mind. *Journal of Medicine and Philosophy* Vol. 32, 1–32.

Drayson, H., 2007. *Gestalt Biometrics.* Mutamorphosis: Challenging Arts and Sciences.

CIANT/Leonardo International Conference, Prague 2007, proceedings pending.

Heidegger, M., 2000. The Question Concerning Technology. In Krell, D. F. (Ed.) *Basic Writings.* London, Routledge.

Ihde, D., 1979. *Technics and Praxis,* Boston, D.Reidel Publishing Company.

Ihde, D., 1993. *Philosophy of Technology: an introduction,* New York, Paragon House.

Ihde, D., 2002. *Bodies in Technology,* Minneapolis, University of Minnesota Press.

Jelen, M. & Biebl, E. M., 2006. Multi-frequency sensor for remote measurement of breath and heartbeat. *Advances in Radio Science* 4, 79-83.

Nye, D. N., 2006. *Technology Matters,* Cambridge, Massachusetts, MIT Press.

Mitcham, C., 1994. *Thinking Through Technology,* Chicago, University of Chicago Press.

Palsson, Olafur S. and Pope, Alan T., 2002. Morphing Beyond Recognition:The Future of Biofeedback Technologies, in *Special Issue:The Future of Biofeedback Instrumentation, Biofeedback,* (30), Spring 2002.

Picard, R. W., 2001. Affective Medicine: Technology with Emotional Intelligence. *Future of Health Technology.* Amsterdam, IOS Press.

The Royal Society., 2006. *Digital healthcare: the impact of information and communication technologies on health and healthcare.* London, The Royal Society.

Schwartz, M. S., 1987. *Biofeedback: A Practitioner's Guide,* New York, The Guilford Press.

Veerbeek, P.-P., 2002. Devices of Engagement: On Borgmann's Philosophy of Information and Technnology. *Techné: Research in Philosophy and Technology,* 6, 69-92.

Winner, L., 1977. *Autonomous Technology; Technics-out-of-control as the Theme in Political Thought,* Cambridge, Massachusetts, MIT Press.

Zakia, R. D., 1997. *Perception and Imaging,* Boston, Focal Press.