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Peering into the Body: Tracing The Visual Culture of Magnetic Resonance Imaging and the Construction of a 'Transparent' Body

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Table of Contents

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and in loving memory of my grandfathers

Abstract

This thesis uses Magnetic Resonance Imaging (MRI) technology as an entry point from which to discuss themes of representation, objectivity, transparency and authoritative knowledge. Popular discourses regarding MRI technologies, and medical imaging technologies more broadly, reflect and reinforce cultural narratives about images and machines. The MRI occupies a privileged position by virtue of being an imaging device in a culture that often conflates images with notions of 'reality' and 'proof' and technology as 'unmediated' and 'objective'. Despite these narratives, medical imaging devices such as the MRI are not neutral procurers of objective knowledge. They are implicated in and reflect the wider culture they are a part of. This work challenges the common erasure of elements such as cultural narratives, a diversity of actors, work practices, human agency and history in the discourse of MRI technology and offers a nuanced understanding of the decisions and context involved in creating scans. In addition it sheds light on how objective knowledge, and authoritative representation are not static, and change over time and how these themes not only add to discourses pertaining to medical images but come to influence our conceptions of bodies, health and control over illness.

Résumé

Cette thèse utilise la technologie de l'imagerie par résonance magnétique (IRM) comme point d'entrée pour discuter de thèmes de représentation, d'objectivité, de transparence et de connaissances autorisées. Les discours populaires concernant les technologies de l'IRM et les technologies d'imagerie médicale plus largement, reflètent et renforcent les récits culturels sur les images et les machines. L'IRM occupe une position privilégiée en vertu d'un dispositif d'imagerie dans une culture qui confond souvent des images avec des notions de «réalité» et de «preuve» et de technologie comme «non médiatisé» et «objectif». Malgré ces récits, les dispositifs d'imagerie médicale tels que l'IRM ne sont pas des chercheurs neutres de connaissances objectives. Ils sont impliqués dans et reflètent la culture plus large qu'ils font partie. Ce travail contredit l'effacement commun d'éléments tels que les récits culturels, la diversité des acteurs, les pratiques de travail, l'agence humaine et l'histoire dans le discours de la technologie IRM et offre une compréhension nuancée des décisions et du contexte impliqués dans la création d'analyses. En outre, il met en lumière comment la connaissance objective et la représentation autorisée ne sont pas statiques, et changent avec le temps et comment ces thèmes ajoutent non seulement aux discours relatifs aux images médicales, mais influencent nos conceptions des corps, de la santé et du contrôle de la maladie.

Introduction

"Art has a double face, of expression and illusion, just like science has a double face: the reality of error and the phantom of truth"
- René Daumal

Images are, and historically have been, central in sharing information in science and in our conception of the human body. The computer screen has become a dominant medium for framing the human body in clinical settings, where medical knowledge and authority are increasingly grounded in interpretation of digital images understood to be faithful representations of otherwise hidden physical conditions. With each innovation in technologies of scientific observation it is often assumed that the human body comes closer to losing its opacity and becomes more easily knowable and navigable. Along with these beliefs come assumptions that medical imaging devices offer up the body's interiority in a 'realistic' manner akin to photography. This line of thinking also hinges on common rhetoric of technological advancement and assumptions that each new imaging device brings with it new opportunities for clearer, sharper and more advanced images. This has in fact been common since before medical imaging technologies as we now know them existed. Starting in the fifteenth century instruments created to aid in the visual representation of the human body have continuously been invented, each with the promise of 'opening up' the body just a little bit more.

Surely there are elements of truth in these claims. Visual apparatuses and technological advancements have been important in expanding scientific and medical knowledge. The purpose of this work is not to suggest that medical imaging technologies are not useful tools in clinical practice, in fact this work is not specifically about medical technologies themselves. The objective of this work is to discuss themes of representation, objectivity and verisimilitude as it relates to visual culture and the body. These themes are discussed through the lens of MRI as a case study in order to ground the arguments, however broader notions of visual culture and the use of visual or graphical representations in science are also raised. Further, this work challenges the myths of linear technological advancement that are present in accounts of medical imaging.

While medical imaging apparatuses provide new sources of information their development and use extends far beyond that rather limited scope. What is often ignored in studies of imaging technologies that focus on clinical application is the degree to which these new visual renderings influence our view of the body, health and disease. Therefore, the plethora of imaging technologies now available to us by virtue of technological 'advancements' do more to complicate our notion of the body than to simplify it. These new images involve new standardizing procedures, new professional training, new types of looking and new ethical dilemmas. Moreover, these imaging devices that are hailed as 'objective' mechanical eyes into the body, that act as if they were windows into previously opaque areas of the human body are, in fact, highly mediated. The more 'advanced' these imaging technologies become the more human mediation is crucial in both the clinical context in which an image is created and the interpretation of the image after the fact. Paradoxically, the more 'advanced' imaging technologies become the further removed human mediation and agency are in the discourse surrounding the devices. This work brings mediation and human agency to the forefront of the analysis to indicate how much more complex these technologies are in both design and use than is usually recounted. I hope to historicize and contextualize these themes by using MRI technology as an entry point from which to examine how they fit into larger cultural patterns and ideologies and underline how science and culture are not as distinct as is often thought.

The first chapter of this work offers an account of the development of MRI technology.

This history functions to contextualize and give background of the MRI as a technological device. It offers insight into the technical components of how the device operates and how it is able to produce a scan and what exactly a scan is able to reflect. This serves the purpose of distancing the technology from assumptions that it operates just like a camera. This chapter describes how the imaging apparatus of the machine creates an image that is a representation of data sets garnered from magnetic waves. It does not show the structure of the interior body so much as it shows representations of magnetic resonance. By underlining this distinction the myths regarding transparency afforded by the MRI to begin to unravel. The MRI is not a camera into the body, nor is it a window. It is a complex representational tool.

Further, the history of its development is outlined in detail and provides a non-linear account of how a method in physical and chemical science turned into an instrument, initially with no imaging component and through a series of circumstances became primarily an imaging technology. This history details how technical as well as social influences were crucial in the development, while neither factor was determinative. The chapter ends with a description of a clinical MRI examination. It outlines the process from a patient's initial visit to a physician, to the process involved in taking an MRI scan to the interpreting the image after. This offers insight into the complex process involved - particularly the significant human mediation and interpretation involved in an MRI examination. This is often overlooked in accounts that position MRI technology as inherently objective and free from human influence or intervention.

The second chapter of this work addresses the common cultural confidence in technology and the supposition that newer imaging devices result in better knowledge and therefore more power over the body. This chapter is rather broad in its scope and introduces themes that will be localized in the context of the MRI in the following chapter. The aim of chapter two is to position scientific images as epistemic objects. This sets the stage to then discuss how it is that images come to stand in for the phenomena they represent. Positioning images as the result of complex negotiation and as a constructive activity in science distances common understandings of images, particularly those created with automation of some sort, as inherently objective. To this point, chapter two chronicles the changing definitions of objectivity from the early twentieth century through to the twenty-first and discusses what digital objective might mean in relation to these changing notions of objectivity. Medical imaging technology purportedly serves to overcome the limitations of human abilities. This chapter addresses this notion and identifies human agency within the production of medical images and the limits of approaching images as objective authoritative facts. Finally this chapter aims to demonstrate that all images, including those seemingly belonging to science are ideology-laden. They shape our perceptions of the phenomena they represent but are reciprocally shaped by the wider culture and ideologies they are a part of.

The final chapter of this work uses themes discussed in chapter two as a foundation from which to anchor an analysis of MRI technology. This chapter first challenges the supposed neutrality of the scans produced with an MRI device. It points to specific instances of human engagement in creating the images as well as the process involved in making sense of the images. Scans need to be disciplined before they are valuable and so while this technology produces a complex image of the body there is an intricate process involved in making the images meaningful- particularly in a diagnostic capacity. Further this chapter looks how neoliberal ideologies impact our conceptions of our bodies and how MRI devices both in clinical practice and in broader culture are popularized in part due to this. The secularization of culture is also discussed as a way healthcare has become moralized and how with this there is a reverent idolization of advanced technologies, particularly medical imaging technologies that may give us more insight into how to protect ourselves from ailments. Following from the themes of the previous chapters the extent to which MRI scans come to replace the physical body in a clinical setting is analyzed. When scans replace the physical body this works to bolster support for the rhetoric that positions an MRI device as force with ultimate agency and authority and as ‘all knowing’. To counter this assumption, the ways in which bodies act as agents of significance on MRI technology is discussed. The ways in which human patients must discipline their actions and behaviors in order to create an effective image complicates the notion that MRI technologies are ‘windows’ into a passive body. The chapter closes with a brief inquiry into the use of MRI images outside of clinical contexts and ways in which seeing these images in popular culture and art become part of our body knowledge and influence our conceptions of our bodies and our body image.

The culmination of this work is a cultural analysis of visualizing the body, through the study of MRI technology. By unfolding the cultural complexities of themes such as representation, transparency, mediation and objectivity in relation to the MRI, I aim neither to place techno-scientific advancements on a pedestal nor to detract from their use as a part of effective clinical and medical care. Instead, this work hopes to demonstrate that medical imaging technologies are a part of visual culture and the examination of them cannot be done in isolation from larger cultural and ideological patterns. By framing my research in this way I hope to add to the existing body of research and offer a new perspective as to how assumptions concerning the objectivity, legibility and verisimilitude of medical images-focusing on the MRI as a pertinent example- are popularized and naturalized.

I

Developing the MRI: Turning Datasets into Visual Representations

"it was eerie. I saw myself in that machine. I never thought my work would come to this"

– Isidor Isaac Rabi, upon seeing his face reflected while inside an MRI machine- a technology derived from his earlier research on nuclear magnetic resonance

This chapter unfolds in two parts. First it gives a technical and historical account of the development of the magnetic resonance imaging (MRI) method. It chronicles its development from the nuclear magnetic resonance method to the magnetic resonance imaging method we know today and gives a brief scientific overview of the technical and scientific procedures involved in the creation of a scan. By discussing these processes it is made apparent that there is nothing inevitable or inherent about the development of MRI technology. The imaging method developed in the way that it did due to the interplay of social and technical forces. By shedding light on the series of innovations, events and influences that culminated in the adoption of the MRI as imaging technology and a diagnostic tool. By offering this history the aim is to showcase the mutually shaping nature of culture and technology and to position the MRI as a device that produces graphical representations of data sets and therefore is not an imaging device in the traditional sense (using mechanical reproduction). This sets the foundation to begin to distance images produced via this method from assumptions of direct bodily transparency. Further, this chapter looks at how professional vision, pre-existing knowledge and expectations on the part of the developers influenced the method and how their decisions turned a method that was initially represented numerically into a primary imaging method. These choices will be examined in the broader context of the cultural values that were dominant at the time the technique was developed and standardized. In addition, by discussing the process of an MRI examination the scans are revealed to be one component of a larger system in determining health or illness. The second aspect of this chapter is to give an account of a clinical MRI examination. As is the case of many technical innovations, human agency is removed from the discourse. Giving a detailed account of the procedures and protocols involved in an MRI examination serves the dual purpose of offering background into the method to set the stage for further investigation of the device and argue that MRI while highly technical is also highly mediated by humans and involves significant human agency in all stages of an MRI exam.

I. Etiology of the MRI Device

The earliest reference to a magnetic instrument was by a 6th century Chinese scientist who described a south pointing ladle- the first example of a compass (Blume 120). However, it wasn't until James Maxwell combined electricity and magnetism in the Maxwell equations and his electromagnetic theory of light that a real foundation for studies of magnetism was created (Isherwood and Worthington 65). His electromagnetic theory of light was "one of the great unifying statements of physics" and set the foundation for Wolfgang Pauli in, 1924, to suggest that certain atomic nuclei behave in a similar fashion to small bar magnets by "virtue of spin and associated electrical charge" (Isherwood and Worthington 65). Because of this Pauli realized the orbital motion of the electrons in an atom could be manipulated by an external magnetic field (Doby and Alker 122). By the 1930s physicists began to discuss the potential of detecting these nuclear activities using resonance methods and in 1939 Isidor Rabi demonstrated this phenomena within a molecular beam (Isherwood and Worthington 65). In the 1940s Edward Purcell and

Felix Bloch conducted separate but similar experiments that measured the 'nuclear magnetic moment' using the same method (Doby and Alker 121). In their natural state the rotational axes of atomic nuclei are aligned randomly. What both Bloch and Purcell discovered was that when an element was exposed to a strong magnetic field the nuclei began to wobble and align according to the magnetic field this is what is described as resonance (Doby and Alker 122). In their experiments, they found that when a radio frequency is also applied the nuclei's axis of rotation changed, and when the wave was switched off they resumed their original orientation. The time that it takes for the nuclei to revert back to their original orientation after the radio frequency wave is shut off it is measured and called 'relaxation time', a central component of what would eventually result in MRI technology.

In a magnetic field resonance apparatus, a set of coils set up at right angles in relation to the magnetic field produce a radio signal .While the nuclei are precessing they are also absorbing some of the radio-frequency energy and when the waves are turned off and they 'relax' the energy absorption is lost and remitted; the emitted radio-frequency can be measured. Ultimately, nuclear magnetic resonance (NMR) - " the reversal of energy - is characteristic of a particular nucleus in a particular magnetic and chemical environment" (Doby and Alker 122). Energized nuclei 'lose' energy by two 'relaxation' processes. This then leads to two parameters called T1 and T2 . T1, alternatively called the 'spin-lattice relaxation' time is "the thermal transfer of energy to the environment, it is the time required for nuclei to realign with the static magnetic field"(Blume 191). The T2 is alternatively called the 'spin-spin relaxation' time. This is the process whereby the precessing nuclei "get out of phase with each other through transfer of energy to other nuclei that were not energized, thus ultimately canceling out the net voltage effect " (Blume191). In sum, Bloch and Purcell's experiments put atoms that have an odd number of particles in a magnetic field and manipulated their orientation by emitting a brief pulse of radio frequency radiation and from here "atoms with appropriate resonant frequency signal could be measured". They found that when an element was placed into a strong enough magnetic field its group of nuclei began to precess and align itself in the direction of the magnet (Doby and Alker 122). Bloch and Purcell, although working separately, shared the Nobel Peace prize for this work. In 1949 copper, hydrogen, fluorine and nitrogen were all studied and it was found that the same atom, when in different chemical compounds, had different resonance frequencies (Blume 191). This discovery along with the fact that NMR can be determined with great precision in both liquids and solids (Doby and Alker 122) became the basis for NMR to be used in the determination of molecular structures (Blume 191). NMR became standard practice in chemistry and biochemistry in measuring relaxation times of chemical samples, and commercial instruments created to aid in the measurement became widely available during the 1950s, noting of course, that the NMR method or associated instillments contained no imaging apparatus at this time. The instruments that were used consisted of small chambers only millimeters to centimeters in diameter that held small samples, although examination of live animal organisms began in the end of the 1960s, at this time it was inconceivable that these tests could be run on a human being.

II. Towards a Diagnostic Method

In the late 1960s, physicist Raymond Damadian developed a theory that when a cell becomes cancerous, it loses its structure as well as its ability to distinguish between sodium and potassium ions and it fills up with water (Blume 193). With this in mind, Damadian argued that there should be a significant difference in the water structure of healthy vs cancerous cells.

Because NMR was a method that could effectively examine molecular structures, Damadian made the link between this knowledge of cancerous cell structure and the properties of NMR spectrometry and suggested that NMR could be used as a diagnostic tool. In 1970, he tested this theory. He took the cells of six tumour filled rats and analyzed them in an NMR spectrometer. The results supported his theory and in 1971 he published a paper in *Science* titled "Tumour detection by nuclear magnetic resonance" (Blume 192). This paper explained that the samples from malignant tumours signaled higher values than the healthy tissue (Doby and Alker 122), encouraging his claim that NMR could be used as an effective diagnostic tool in cancer detection.

During the same time, John Mallard a medical physicist at the University of Aberdeen came to the same conclusion as Damadian and began to frame his study of NMR in terms of its diagnostic potential. This focus on diagnostics was a natural progression for Mallard given his previous background in attempts to develop new medical diagnostic modalities. In the early 1960s Mallard was attempting to develop the possibility of tissue characterization using electron spin resonance (ESR). His work produced some publications but the program was ultimately terminated. When Damadian's 1971 paper was published, Mallard realized they both were working on similar goals, using different technology (Blume 194). Damadian had trouble obtaining funding, but in 1972 he secured a three year grant from the National Institute of Science. During this time he continued to pursue the diagnostic potential of NMR suggesting,

> "methods to date are mainly descriptive, relying chiefly on the appearance of tumour specimens in the light microscope. Apart from acknowledging the added power discrimination implicit in the assignment of a number to an observation, it is worth noting that although a chemical reagent is the ultimate objective of a cure for cancer, study of

this disease is largely devoid of a chemical database and remains rooted in morphology" (Damadian et al.).

What was significant about NMR for Damadian was that rather than classifying tumours based on their appearance under a light microscope, they could be classified based on their chemical structure. This claim was not without criticism, however. Many critics challenged Damadian's logic arguing that the T1 elevation in the tumours was not due to some inherent characteristic of carcinogenesis that directly leads to changes in the structure of the tissue water but due simply to higher water content and therefor could not conclusively prove cancer. This was problematic to Damadian's argument because there could theoretically be other causes of higher water content , such as traumatic or inflammatory conditions (Blume 194).

Up until this point no reference to NMR imaging had been made. Damadian had argued a link between NMR signals and cancer detection and others eventually followed suit and by 1976 he would develop a technique, developed using magnets of his own creation, that could "produce an image of the body and localize the abnormal areas" (Doby and Alker 123). He called this technique 'feild-focused nuclear magnetic resonance' or 'FONAR'. But it was Paul Lauterbur, a chemist that first suggested a connection between NMR and imaging. Lauterbur decided that for diagnostic purposes, imaging would be crucial and so he began to work out the mathematical calculations to do it.

Lauterbur was first interested in a similar method called Electronic Spin Resonance (ESR). During his time served in the military, he was introduced to NMR when a soldier in a nearby laboratory acquired an NMR spectrometer. The spectrometer was bought to use up the leftover budget and no-one really had a sense of how to use it. Lauterbur, with his experience in ESR, was able to apply for a transfer and began to tinker with the device (Dawson 43).

Eventually Lauterbur learned that images could be made by “placing a gradient of magnetic field across a sample” (Dawson 43). These images though were somewhat inefficient so he simplified the method by “applying a linear gradient of magnetic field across the sample. Because the nuclei in the sample produce signals at different frequencies along this gradient, the value of each frequency serves as an address, a Zip Code, indicating where in the sample each signal has originated” (Dawson 86) . From here he began to work on the mathematic equations that would help him connect these ‘zip codes’ into an image. During this time, no computer of any sort was used. Instead, numbers were read and penciled into a grid and the images were produced manually. He soon began to ask around, to different computer scientists and mathematicians if a method he called “projection reconstruction” could potentially be used to produce images. He explained the method as follows,

> “Sets of linear gradients oriented in different directions could uniquely encode each of a finite number of points representing the object, and I thought that an iterative comparison of the ‘projections’ thus generated with those from images, progressively refined to minimize the differences, could converge on a correct solution. In iterative techniques a preliminary solution is obtained, and then the parameters are automatically changed so that differences between the observed and computed points are minimized, and a new solution (in MRI a new image) is computed” (Dawson 87-88).

Many of the experts he consulted told him that this method was impossible, until a computer scientist at Stony Brook pointed out a recently published paper that discussed an algorithm for image computation that was more or less identical to that of Lauterbur’s ‘projection reconstruction’ (Dawson 44). Although there was still a ways to go in developing the algorithms and computer programs that make up modern MRI, this was a crucial step in making the link between NMR and NMR as an imaging method.

Lauterbur called this process ‘zeugmatography’ from the Greek ‘zeugma’ - to join together. This process joined together not only NMR numerical data and computer images but also disciplines, (chemistry, physics, computer science, medicine) which would become more apparent as the exploratory phase of zeugmatography continued. What is noteworthy about Lauterbur’s approach thus far is that he was very much focused on the imaging aspect of the method and stressed that the image above all else was “*the* component of NMR data to be produced and used” (Joyce 35). Many of the scientists working on NMR rejected this notion and continued to include numeric measurements, feeling that without numerical representation key information could be lost. The scientists, used to working in labs and with training in documenting results in such a qualitative fashion were resistant to the notion that an image could stand in for such a complex system of information. As development continued images increasingly became central and so the scientists not only had to adjust their expectations in producing these images, they were required to design the ‘aesthetic’ of the images. Again, the developers of NMR were not trained in medicine and had little to no experience with anatomical images. Therefore, not yet creating the technology specifically for use in clinical settings and having to answer to traditional industry expectations of medical imaging apparatuses of the time, they represented the interior body in vibrant shades of green, yellow and red. The early innovators of NMR chose an aesthetic influenced by the popular culture of the time, a decade notoriously remembered for the work of Andy Warhol, lava lamps and psychedelic colours (Joyce 35).

Throughout the early 1970s Damadian and Lauterbur were locked in a fierce race to become the first to produce an NMR image. Lauterbur, in 1973, produced the first computerized image of small water filled tubes. At this time research teams in Japan, the United States, The United Kingdom, Switzerland and Scotland started to build from Damadian and Lauterbur's research and began the process of transforming this knowledge and new techniques into feasible medical technology. In 1974, using Lauterbur's method which had been published, the first image of a live animal - a mouse - came out of Aberdeen Scotland by a research team lead by John Mallard. These results spurred interest in a number of researchers globally. While Damadian, Lauterbur and Mallard had been inspired by the diagnostic and medical potential of NMR other research teams, most significantly Raymond Andrew and Peter Mansfield from the physics department of Nottingham University, had been intrigued simply by the challenge of improving Lauterbur's technique. During the war, Andrew who worked on radars, began to devote his career to radio frequency spectroscopy. After reading Lauterbur's publication he attempted NMR imaging himself and decided "there might be a better ways of doing it that did not require the large signal handling and computing facilities needed by Lauterbur's method" (Blume 197).

Similarly, Mansfield saw commonalities between his own work in physics and Lauterbur's work. Mansfield, in 1973 had published an innovative method for forming one-dimensional proton density, a project that was along the same lines as Lauterbur's NMR albeit on a smaller scale.

All teams eventually became enthused by Damadian's original yet controversial notion that there is a relationship between relaxation time and cancer detection. Mallard approached NMR as a general imaging method while Andrew focused specifically on tumour detection. This interdisciplinary approach between physics and medicine was at the time somewhat novel and the physicists used this to their advantage securing funds from the Medical Research Council with the promise that their work had significant medical implications. In this respect, NMR was only opportunistically framed as a distinctly medical or diagnostic device.

With diagnostic potential now at the core of NMR research this began to shift the focus of the projects. All of the tests unto that point had been executed using specimens no larger than 1 cm (Blume 200). This became problematic as the guarantee was that this imaging method may be used on humans, naturally, finding a way to scan larger specimens became of the utmost importance. It was soon discovered that the larger the specimen the longer it took to produce an image. Under the initial goals of Andrew and Mansfield this may not have been a problem, given that they were originally interested in perfecting the technical aspects of the scanning method. However, given the medical focus of the research it became imperative that the time that it took to produce an image be cut down so that it may be more effectively used in a clinical setting with human subjects. A key point where the social demands of implementation bear down on the process of "technical" innovation. Additionally, for Andrew and Mansfield's teams, "it became necessary to provide anatomical drawings or other means of validating NMR images, and as audiences to be addressed changed medical collaboration became all the more vital" (Blume 200) particularly for the physicists who had to work to build up a network of medical contacts. Damadian and Mallard on the other hand began to conceive of ways to make their work as effective as possible for clinical medical practice. Both scientists benefited greatly from their backgrounds in medical physics as well as their professional networks. Mallard as well began to take into consideration eventual human subjects. For him, his central goal was building the machine so that it was not incredibly sensitive to patient movements, a clearly clinical goal.

III. Clinical Applications of a New Method

In 1974, Damadian received the patent for his FONAR method (which he applied for two years prior) and using this method he was able to image the thorax of a live mouse. Following this success but without the funds to commission a magnet large enough, he decided to build his own. The first successful image produced using the FONAR technique and Damadian's giant magnet was his colleague's chest; it took four hours and forty-five minutes (Blume 206). Damadian was quick to publish his results, but the reviews again were mixed. Critics still found issues with the notion that while the images could detect cancerous tissue, could it differentiate between cancer and other abnormal pathologies?

During this same time frame neither Andrew nor Mansfield had begun to attempt full body imaging. Instead their work continued to focus on improving the image quality, particularly of complex anatomical structures and imaging time. In 1978 Andrew and Henshaw published an image of the head of a rabbit that greatly exceeded the quality of Damadian's chest image and claimed to take between eleven and eighteen minutes in imaging time (Blume 208).

Eventually, Andrew decided to attempt work on full body imaging. In order to do so he commissioned a large magnet, but with the clinical use of the machine in mind he chose to switch the type of magnet originally used in his work to a type of magnet that was 500 000 dollars cheaper, required less power, and was significantly lighter, making it more adaptable to a hospital setting. Mansfield and Mallard eventually began the task of full body scanning both focused on reducing imaging time. Andrew's team was busy with patients being sent to him from the university hospital, and soon it became apparent to him that he would have to continue to think about how the machine may be remodeled so that it would be effective in the context of a hospital. His team soon became focused on working on the sensitivity of the magnetic field to non uniformity so that factors such as iron (which was abundant in hospital buildings) would not have a problematic impact on the imaging process.

Damadian, ready to leave the university and take control of his imaging technique and machine - for fear that big business would steal his work, set up a company of his own naming it FONAR Corporation (Blume 213). With this of course Damadian too began to rethink the technology in terms of commercial use due to the ever growing importance and interest in the diagnostic potential. He made several changes to the machine, most significantly he too decided to change the magnet type so that it would be more conducive to clinical or hospital settings. The FONAR Corporation brought to market the first commercial MR scanner in March 1980 called the QED 80. Lauterbur worked with electronics company Phillips to create a prototype that was released by 1981. A survey by the Office of Technology Assessment indicated that by 1983 there were twenty firms with a commitment in NMR imaging development, six of which were specialized specifically in NMR (Blume 215). By 1985 FONAR, Diasonics, Picker International, Technicare, and GE all had been given market approval by the FDA. With this, a new approach to knowing and seeing the body was made available for clinical practice and public awareness. This 'way' of knowing the interior body was multicoloured, consisted of the relaxation times of nuclei, involved images accompanied by some numerical notations and is produced by a process called Nuclear Magnetic Resonance imaging.

Once NMR imaging machines entered clinical practice, the question became, whose professional domain would the device fall into? At the time there were a few seemingly viable options. NMR having its basis in nuclear science could potentially have been placed under the jurisdiction of nuclear medicine physicians. These physicians, trained in chemistry and physics as it relates to the body, would have the training and the professional experience to read the numerical data that, at the time, was printed along with the images. For the same reasons, departments of pathology could have potentially housed the new technology. That being said, the machine did have an imaging component was well, which made radiologists very much interested in securing it under their domain. Radiologists, whose professional vision is oriented around being able to order and comprehend the body via various anatomical images argued that NMR imaging would mesh naturally with their knowledge and approach to understanding the body. Some disagreement between nuclear physicians and radiologists occurred throughout the 1980s as each discipline believed that the other was putting too much emphasis on one component of the machine. Radiologists believe that under the jurisdiction of nuclear physicians the images would be overlooked while nuclear physicians believed radiologist would rely too heavily on the images would result in incomplete information that could be provided by the accompanying numerical data (Linton 80)

In the end, NMR imaging became part of radiology departments, partly due to the climate of radiology departments at the time. The American College of Radiology had been previously successful in securing imaging methods such as ultrasound and computed tomography (CT) and at that time there was a policy imposed by the Joint Commission in Accreditation of Hospitals that declared that its participating institutions must have all imaging procedures interpreted by a radiologist (Linton 81). In this instance, a social and institutional organization, a non-technical factor, had a significant influence on the technology, practice and development thereafter. Placing NMR in radiology departments greatly influenced further developments of the machine. Again, it is apparent how professional training and socio-cognitive factors shape the materiality of the NMR device. A radiologist's expertise is to be able to identify and understand the body, health, illness and pathology in sets of images (up until this point the images were black and white - think Xray). This is significant in that there are other ways of course to ‘view’ the body and its ailments, for instance in numeral data sets. The technology however through its previous development as an imaging device and then housed in radiology, a department that specializes in imaging became further ‘coded’ as primarily an imaging device. Feenberg discuss the concept of a ‘technical code’ explaining,

> “A technical code is the realization of an interest or ideology in a technically coherent solution to a problem. Although the technical codes are formulated explicitly by technologists themselves, the term I use it refers to a more general analytic tool that can be applied even in the absence of such formulations. More precisely then a technical code selects between alternative feasible technical designs in terms of a social goal and realizes that goal in design. “Feasible” here means technically workable.” (68)

In the development of NMR, the scientists encoded imagery as the primary element of the method. While it would have been equally feasible to gather the same data without the imaging component, imaging became a crucial goal in the design of the technology. This emphasis was then reiterated when the machine became part of radiological practice. When the machine was placed into radiology departments the printing of both numerical information along with the images ceased. Radiologists did not have the professional knowledge or training to interpret numerical data sets and so they had no use for them. All the information a radiologist needed was contained within the image and in the medical file of the patient. Eventually, much like the CT device, once it was in the domain of radiologists, the numerical data no longer was printed (although it could be accessed on the computer if searched for) ultimately leading newer generations of the device to only include the images (Kevles 161). Furthermore, once under the domain of radiologists, the images that were once displayed in multicolour became grey scale.

With experience in interpreting X-rays and CT scans, a radiologist's visual training was specific to interpreting black and white and grayscale. The multicoloured displays would have required new training and a shift in visual practices within the discipline. Instead the technology was adjusted to reflect the professional training and practices of the experts involved as well as the technical code that was instilled in the device.

Up until this point in its history the technology in question had been referred to as NMR imaging, but in present day it is called MR imaging. This change in name was promoted by American Dr. Alexander Margulis who suggested the word "nuclear" be dropped and that instead it simply be called 'magnetic resonance imaging' (Joyce 42). This change came as a result of the political climate in the United States during the late 1970s to early 1980s. During this time period nuclear weapons and nuclear power plants were very much a part of the cultural consciousness. There was public concern about the dangers of nuclear energy and growing tension about the nuclear arms race. It was in this climate that NMR imaging entered clinical practice and because of this it was difficult to separate 'nuclear' science from connotations of danger, violence and health hazards. This shift in renaming the technology further indicates the interplay between mass culture and science that is the emblematic of the development of the MRI.

Moreover, in a cyclical fashion, the renaming of the device resulted in implications on the cultural understanding of the device. Joyce notes,

> "the removal of the word nuclear not only distanced the technology from its roots in physics but also made it more difficult to imagine the MRI as a producer of information about one's nuclei. In contrast, the new name, magnetic resonance imaging, through its emphasis on images, discursively transformed the machine into an imaging technique. In

doing so, it aligned the new technology with the visual and singled the increasing importance of visualization and biomedicine in the late twentieth century" (42).

Putting emphasis on the imaging aspect of the device puts the numerical data, a key function of the device, into the shadows. This makes it easier to make links between MRI and mechanical imaging such as photography and assumptions that imaging technologies such as MRI act as direct windows into the body. Images of this type are particularly persuasive due to their context in being produced in a clinical setting. At the same time that they share connotations of the objectivity of photographs they are implicated in notions of objectivity and authority that is associated with science and medicine.

Tracing the history of MRI development serves a number of functions. First it provides an entry point to study the MRI as much as a cultural object as a medical one. The MRI is a textbook example of how the development of any technology is not linear and involves a number of forces, actors and networks that all mutually influence each other. As Bijker and Law point out "it is impossible to pry technical and social relations apart. The shaping of a technology is also the shaping of a society, a set of social an economic relations" (105). This very notion is present in the history of the development of the MRI in that the technology was advanced in the way that it was due largely to the competing professional visions of the scientists involved, their backgrounds and training. While in the end the MRI became a medical tool its roots are in physics and chemistry, developed within university laboratories by scientists with no abundant medical connections or resources. This had implications on what was prioritized in the technological development of the method. Damadian championed the NMR method's ability to detect cancer from the beginning stages and Lauterbur was quick to concur. This set the stage for the imaging potential of the method to be predominant. Andrew and Mansfield however were drawn to NMR due to their previous research on similar techniques. Their ambition in taking up Lauterbur's work did not stem from interest in the diagnostic potential of the method but instead was regarded as a project that would test their ingenuity as physicists. They simply believed they were capable of improving Lauterbur's method. Eventually, MRI was approached as a diagnostic tool from all development teams but this was done through a process of negotiation. What began as an instrument in physical and chemical science and experimentation came to fruition in the medical-clinical setting of the practice of radiology. Both factors influenced the eventual shaping of the technology, but neither alone was determinative. As Madeleine Akrich suggests "machines and devices are obviously composite, heterogeneous, and physically localized. Although they point to an end, a use for which they have been conceived, they also form part of a long chain of people, products, tools, machines, money and so forth" (205). Such was the case with MRI, factors such as grants from medical associations, interdisciplinary connections among developers and rising clinical interest further shaped how the MRI developed as a medical tool.

This history illuminates the cultural context a technology is developed in is significant in the ultimate direction it takes and therefore worthy of study. The scientists who created the MRI were, to some extent, blank slates in terms of their previous knowledge of anatomical imagery. They were not physicians or radiologists familiar with current and previous imaging forms. Because of this, when deciding on how to represent the NMR data in visual form they were inspired by the popular culture and art aesthetics of the day, choosing vibrant images, only to be reverted back to greyscale once under the domain of radiologists. The name change from Nuclear Magnetic Resonance to simply Magnetic Resonance is reflective of a culture of fear and uncertainty about what nuclear meant in terms of safety. The development of MR imaging was not simply a series of technical innovations developed in a vacuum solely based on the science involved. The scientist's life experiences, opportunities for funding and wider culture worked together to shape the technology as well as its purpose, and later adoption into clinical practice.

That is not to say that the relationship is unidirectional, the adoption and widespread use of the MR imaging method has had effects on culture as well. Slack and Wise argue there is not 'technology' and then 'culture', we live in technological culture. Culture and technology exist in tandem, shaping each other therefor narratives that naturalize the notion that medical imaging devices 'see' illness and 'see' into our bodies with absolute authority exclude the notion that culture acts on technology as well. Offering a history and identifying the various actors , human and nonhuman (Latour) begins to poke holes in the 'blackbox' conception of medical imaging devices. Madeleine Akrich argues,

> "it is important to move constantly between the technical and the social. We also have to move between the inside and the outside of technical objects. If we do this, two vital questions start to come into focus. The first has to do with the extent to which the composition of a technical object constrains actants in the way they relate both to the object and to one another. The second concerns the character of these actants and their links, the extent to which they are able to reshape the object, and the various ways in which the object may be used. Once considered in this way, the boundary between the inside and the outside of an object comes to be seen as a *consequence* of such interaction rather than something that determines it"(206).

In this case looking at the different technical, cultural and cognitive actors involved paints a picture of MRI development as a consequence of a number of forces that when co-occurring in the way that they did, created the MRI machine along with its uses and practices that we know today. If the actors had been different the machine could have been developed in a different way, there is nothing natural about the MRI as we have it today and therefore nothing natural about our visual understanding of illness and the body.

Aldrich acknowledges the importance of looking at the full context of any device, the inside and outside that is the technical and social, but further, we should look at the inside of technologies themselves. The materiality of technologies gives an entry point to unpack the ‘black box’. Historicizing its development makes clear that MR technology is primarily a measurement device and only became an imaging technology through a process of development that included a number of non-technical and non-scientific actors. Looking 'inside' the technology and taking into account its materiality and technical features complicates simplistic assumptions that MR imaging works in a similar way that a camera does, and that scans offer a window into or are snapshots of the inner body. When it is commonly understood as an imaging device, MRI loses its ties to chemistry and physics. This is significant in that it then seemingly appears to be a mechanical imaging device similar to a camera. This bolsters assumptions that MRIs and similar technologies ‘peer’ into the body and allow us to ‘see’ when in fact, the images are graphically representing numeric data sets.

Understanding the properties, practices and standards that gave rise to the machine as well as the materiality or the ‘technology itself’ demystifies the MRI as a window into the body and instead positions it as a complex system of technologies and networks working in tandem. By addressing the materiality of the device we can study how its affordances impact our understanding of the body. For instance, what impact did radiologists’ decision to not print numerical data have on the later materiality of the device? How did this change affect common conceptions of the cancer as visualizable? What would it have meant for the materiality of the device not to have changed and included numerical data alongside the images?

IV. MRI Examination: Procedures and Protocols

The second objective of this section is, by demonstrating both the history of the MRI as a complex method of imaging derived from physics and chemistry and as a consequence of a number of sociocultural and socio-cognitive factors, to complicate the notion of MRI as imaging in the same way that photography is imaging. After investigation of the technical properties and development of the MRI it is evident that MR images are not photographs or even really images of anatomy. Instead they are representations of atoms absorbing and remitting energy. As well, the imaging process does not yield one complete, concise image. Generally, sets of 20 images of proton density, T1 and T2 weighted images for two of either axial, coronal or sagittal planes/sections are taken. These 20 images are also of a particular 'slice' thickness measured in millimeters. The images are "taken sequentially from top to bottom, right to left, or anterior to posterior of the particular body part that is imaged" (Prasad 294). In total, in one MRI exam there are usually about 120 images taken with sets that use different combinations of types (T1, T2 , proton density), sections (axial, coronal, sagittal) and different slices. Further, these images are created from numerical data - the resonance frequencies of different atoms.

The common understanding of medical imaging is that we can simply go in a take pictures of the body, much in the same way we can take evidence pictures of a crime scene and uncover 'truth' or in this case a diagnosis. The issues with photographic images as evidence has been discussed at length particularly that there are always subjective choices such as framing or positioning that may bias an image. Donna Haraway sums this notion up well when she suggests, "there is no unmediated photograph or passive camera obscura in scientific accounts of bodies and machines; there are only highly visual possibilities, each with a wonderfully detailed, active, partial way of organizing worlds"(394). These same issues are present in MR imaging as well although they are often overlooked because they are implicated in the objectivity and certainty that is associated with science. Additionally, often overlooked is the agency and the impact of the choices made by the radiologist on the results of the examination. Thus far we have discussed the science behind and the historical development of MR imaging and how understanding these factors begins to poke holes in common conceptions of MR scans as infallible, authoritative tools that render the body transparent. To further this, it is perhaps apt to consider the process of an MR exam in a clinical setting, particularly the human agency involved in producing images.

The modern MRI machine is made up of a long tube and a circular magnet. In order for scan to be taken a coil is strapped to the body part of the individual that is being examined. There are different, specially designed coils for particular body parts (i.e., torso or head coils). These coils are designed to register signals of relaxation times or proton density of atoms from the interior of the body. Once the technologist, who is responsible for operating the machine within the radiology laboratory, fits the patient with the appropriate coil the patient enters the machine, usually lying down and the technologist relocates into a separate room. In that room there is a computer and a display that is connected to the MRI machine. The two rooms are joint but separated by glass so that the technologist can monitor the patient and the machine while simultaneously operating the computer.

The objective is that signals will be passed by the coils, which then are turned into images "with the help of a computer after numerous acts of 'shifting' and 'working on'" (Prasad 293). In order for this to be done effectively, not only do the mechanics need to be operating properly and the technologist competent, but much is dependent on the patient's cooperation. There is a microphone inside the tube, where is patient lays down so that the technologist and patient can communicate during the process. While there are techniques intrinsic to the machine that cancels out electronic ‘noise’ or minimize physiological moment inside the patients body (such as a heart beat) it is crucial that the patient stays as still as possible while the imaging is taking place and data is being collected. Movements during the imaging process can lead to ‘artifacts’ on the scan which can impede analysis and diagnosis.

Before the imaging process starts, a physician meets with the patient and usually preforms an examination and takes note of ailments and symptoms. Based on the information gathered during this interaction the physician makes a decisions as to whether sending the patient in for imaging is appropriate and if so, which body part needs to be assessed. This information is then usually sent to a radiologist who reads the physician’s notes and determines the types of techniques that should be used during imaging to gather the right information and create the appropriate images. It is at this point that the technologist, responsible for the act of creating the images and operating the technology is given the radiologists instructions and based on these instructions preforms the imaging exam. That being said, the technologist “is not an automaton” (Prasad 294). The technologist has a significant amount of agency and must make decisions while operating the machine. For instance, while they are given instructions about the specific body part that must be examined and the techniques to be used, it is the technologist’s job to ensure that the body part comes our clear and focused in the field of view of the machine. Depending on what the technologist encounters during his or her process he or she may ask the radiologist to add contrast agents or produce additional images using a different set of imaging techniques. For instance, Prasad explains a case where “a technologist was imaging a patient’s ankle, she realized that there was something unusual at its lower edge. As she shifted the focus, a large blob came into view, which was later identified to be a blood clot and the source of the patient's pain" (294). In this case although instructions were given by a physician and a radiologist this 'blob' was nearly missed, and was only observed in the final stage of the imaging process. This complicates the assumption that imaging is perfect and exists outside of 'human error'. There is a common conception that places computer technologies on a sort of pedestal, with the assumption that they are more accurate and efficient than humans. This thinking assumes that humans and technologies exist separately. This is simple not the case. In much the same way there is no technology and culture, rather technological culture, one cannot truly separate humans from technology. In this case specifically, not only were human choices present in the development of the technology but they are extremely important in its daily operation. The process of an imaging exam first begins with human interaction, between patient and physician. It is the physical examination of the patient by the doctor that creates the basis of the imaging exam. It is from this examination that parameters to be images are set, what to look for and how it should be done are determined. A radiologist and technician's decisions and execution of techniques heavily influence the scan that is produced. The point being, MRI devices are not independent agents that act upon the body to give information about the inner body, it is a negotiation between human and non-human actors that produce the final scans.

Not only are the techniques and parameters that are set by the radiologist and technician important but so is their experience, knowledge and professional vision. The images that are created from this process have no real visual relationship with how unaided eyes are used to seeing the body. Because of this there is a high degree of trained vision and interpretation required to see and assess information from these images in order to make decisions about pathology or disease in a clinical setting (Waldby 28). About 120 images are taken in a typical examination. While each of these images separately is two-dimensional, together they offer a three-dimensional account and 'view' of the body part being examined (Prasad 294). The images are printed out immediately to ensure that if there is any blurring they can be retaken. The images are kept on the computer for a period of time (usually a few days) in case there are other reconfigurations of the body part that are needed. The printed images (scans) are then sent to the radiologist who mounts them onto a large display board in order to analyze them as a complete set while also being able to analyze differences at a number of smaller more concentrated levels. Because there are a number of ways the radiologist could analyze or 'view' the images, he or she limits his or her 'vision' to the notes and questions that the physician had previously made. Of course, if there is something obviously alarming in the scans the radiologist will address it but other than that their vision is influenced by the physician's examination and the instructions given. The radiologist then makes a note of his or her analysis. Key to the analysis of these images is comparison. First, the images are compared to each other. One level of comparison is often to compare the images on the different plane levels. For instance in a spinal cord a "sagittal section can show whether the different bones constituting it are compressed or broken, while the axial section can show if such compression is causing a blockage of the spinal cord"(Joyce 443). In addition, the radiologist will compare blurry or otherwise seemingly strange appearances on the scans with a catalogue of MRI artifacts. Finally, there is often comparison on the level of the T1 and T2 images, and proton density images. For instance, when comparing these images it is known that cancerous lesions appear as dark spots on T1 images and as bright spots on T2 images. Comparing the two types of images with each other offers substantial causation for a differential diagnosis.

Second, the images are compared to 'normal' images of pathology or anatomy from anatomical atlases. During the process of analysis not only are the scans compared to each other but there is often a schematic diagram or body atlas present that acts as a baseline from which to compare. These atlases are made up of a number of MR and schematic images that have been deemed ‘standard’ pathological anatomy. That is not to say that there isn't additional knowledge required by the radiologist that comes from experience as each body has variation to some extent. Moreover, the radiologist’s concern is not to decipher the anatomy in complete detail; their vision is set to a specific section of the body but this vision is made possible by their training in “understanding and interpreting the anatomical details of the whole body, for which MRI and other standard anatomic body atlases serve as useful tools” (Prasad 293). That is to say, while the scans represent sections of the body at a time, the radiologist must have knowledge of the anatomy of the entire body to make sense of the fragments. In order to make these “two levels of viewing work complementarily, the body, as it is presented in the body atlases, is made notational (i.e., converted into sets of isolable disjoint, and differential parts). This process allows radiologists to visually extricate the pathology without worrying about the complete anatomic details of the body part that is being examined” (Prasad 293). These images are contingent because new information may become archived and become standard “however if some significantly different normal or pathological variations are observed, sooner or later they get archived, thus becoming a part of the encompassing viewing of the body.... as new ‘facts’ emerge, the analysis also changes”(Prasad 298). Thus, everything from the scans to the atlas images to the notes from the doctor becomes the toolkit for the radiologist’s complex professional vision. Vision in this sense is a complex process that undergoes negotiation. Sturken and Cartwright discuss “the myth of photographic truth”, the notion that

> “despite the subjective aspects of the act of taking a picture, the aura of machine objectivity clings to mechanical and electronic images. All camera generated images, be

> they photographic, cinematic, or electronic (video or commuter-generated), bear the cultural legacy of still photography, which historically has been regarded as a more objective practice than, say, painting or drawing" (16).

Photography was invented during a historical period where there was a strong positivist approach to science. This positivist approach dictated that 'truths' could be known if there was visual evidence to support them. Cameras had connotations of objectivity and were understood as a "scientific tool for registering reality and was regarded by its easy advocates as a means of representing the world more accurately than hand-rendered images" (Sturken and Cartwright 17). This same approach rings true to the common understanding of MR imaging today. The discourses sounding the scans are often ones that talk of objectivity, truth and authority. As this section has pointed out, not only are human decisions of framing the image present in the production of the scans, but these images are not photographic. While they excite very similar reactions and discourses as images produced by photographic cameras they are worlds apart in how they produce images. In MR imaging there is no camera. Images are not pictures of the body in the way a photograph is. The multiple digital scans that make up one exam are visual representations of resonance in a magnetic field.

In sum, this chapter offered a history of MRI development as well as a technical account of the science involved in the imaging process. MRI developed from the NMR method that measures the relaxation time of nuclei when in a magnetic field. Damadian first suggested that the NMR method could be used to detect cancerous cells and while this theory was contested at first, eventually research teams all over the world began to work on NMR methods of diagnosing cancer. Imaging was not a component in the original NMR method but became central when Lauterbur became focused on perfecting the imaging potential of the method, first manually and then by a series of algorithms he called ‘projection reconstruction’. While Damadian and Lauterbur’s central aim was to be able to use NMR to detect cancer on a chemical, cellular level others such as Andrew, Mansfield and Mallard had different aims such as perfecting the physics behind the method, not necessarily focused or even aware of the medical potential of the method. All of the scientist’s interest and focus in the development of the method was influenced by his own professional training and knowledge. None of the initial developers of the future medical imaging technology were physicians or had any concrete experience with medicine, anatomical images or clinical settings. By outlining this history, the intent is to demonstrate the importance of realizing the different actors and networks involved in any one technology. These scientists due to a number of factors had to negotiate what their new method meant. NMR (later renamed MRI) initially had no imaging modality, instead it included numerical data in response to relaxation times and T1 and T2 measurements. During the development process a technical code that centred on representing these values in images became negotiated. This is significant because MRI is now implicated in notions regarding its ability to be a ‘window’ into the body, its ability to ‘see’ or visual illness into images and this seems matter of fact and natural. In reality, had the actors involved developed differently or had MRI been housed in a department other than radiology it could have been numerical data that was central to the diagnostic method instead of images. Further, while MRI as an imaging device has cultural implications (i.e., how we visualize illness) culture was very much a part of the MRI’s development. Initially, scans were multicoloured, reflecting the aesthetic of the time. It was only once it entered radiology departments, where the radiologists were accustomed to reading black and white images that the scans where changed to greyscale. Nuclear Magnetic Resonance (NMR) was changed to Magnetic Response Imaging (MRI) in an attempt to distance the method from the term nuclear.

The cultural climate connoted nuclear with danger, threats and violence so instead the renaming distanced the method from its roots in chemistry and instead focused on its use as an imaging method. By giving a technical account of how an MRI works the notion of an MRI as being an imaging modality akin to a photograph was challenged. This chapter in part works to juxtapose ‘traditional’ mechanical imaging technical processes to the technical process of creating an MR image. The purpose of this is to demonstrate that while often thought of in the same manner as a photograph, an MRI scan is a visual representation of data set and therefore does not truly mechanically reproduce the interior of the body. A detailed account of the science behind the imaging component of an MRI device makes clear that the scans are data about precessing of a nuclei within a magnetic field computed into 120 images and not a mechanical reproduction of the inside of the body. Looking at these processes in their social context works to complicate and denaturalize myths regarding the authority and seeming objectivity of MRI scans.

The second aim of this chapter is to give an account of the typical process of an MRI examination and explored how scans are one component of an exam that is put into context with anatomical atlases, radiologists’ previous knowledge of anatomy and physicians’ notes. This process demonstrates that a scan is not produced outside of human influence, rather choices made by the radiologist technician operating the equipment and his or her knowledge of the body are crucial in producing a scan and producing a scan with appropriate information. Together these historical and technical accounts work to complicate common rhetoric that suggests that medical imaging technologies offer transparent knowledge on the inner body and disease and that a device such as an MRI is an agent in and of itself that diagnosis or ‘sees’ oppose to one actor in a series of process that ultimately when combined result in an MRI examination. By ‘un-black boxing' the technology in this way opportunities for studying cultural values, subjectivities and ideologies that are historically rooted in the device, its development and adoption are unearthed.

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II

Images in and of Science

"Indeed, we often mark our progress in science by improvements in imaging."

– Martin Chalfie

A central argument in this work is that the development and deployment of medical imaging technologies- particularly the MRI – is part of a broader set of socio-technical and cultural networks implicated in the turn towards visualization in scientific practice. Computer based imaging technologies have become central to modern epistemologies of the body and health. In order to more closely look at the visual power of MRI images, cultural narratives of objectivity in relation to visual images in science more broadly must be taken into account. The first half of this chapter chronicles the shifting connotations of objectivity in science, particularly mechanical objectivity. Computer generated imaging technologies are hybrid technologies with visual displays that are reminiscent of photography even though their images are produced in a very different manner. Still, they are implicated in the cultural meaning of truth and objectivity attributed to photographs; therefore this work examines how these connotations get carried over to digital objectivity. The second half of this chapter positions images as epistemic objects that generate meaning not only in the data they convey, but also in the methods and processes by which they are produced. By positing science and scientific fact as a constructive activity, this chapter looks at how images are constructed in science and how, due to their connotations of truthfulness, objectivity and authority come to stand in for the phenomena they represent. This lays the foundation to then begin to look at visual representations as sites of analysis themselves and how they come to act on understandings of the phenomena they represent. In chapter 3 of this work these questions are asked again, localized in the context of MRI images and the work these representations do in our understanding of the body, health and illness.

I. Rise of Mechanical Objectivity

Lorraine Daston and Peter Galison write a history of objectivity, primarily mechanical or the 'new' objectivity that emerged in the mid nineteenth century. This exploration is perhaps at first counterintuitive. Objectivity is a concept so naturalized that its history, or even the idea that it might have a history, is largely overlooked. In this important text, Daston and Galison compare shifting understandings of what it meant to be objective in the early nineteenth century through to the end of the century, localizing their study in anatomical atlases produced during this period. Their focus is primarily on the second half of the 19th century. During this time, atlases were in abundance and "became manifestos for the new brand of scientific objectivity" (81). This 'new' objectivity hailed machines for their ability to seemingly remove the "frailties of the flesh and spirit" and to "let nature speak for itself"(83). In this manner, objectivity is typically understood as the "opposite" of subjectivity, with the latter associated with the distorting influence of human mediation, representation and interpretation. However, as Daston and Galison suggest, subjectivity also has a history and fluctuating connotations. The history of "various forms of objectivity might be told as how, why and when various forms of subjectivity came to be seen as *dangerously* subjective" (82).

All types of objectivity are presented as corrective to some aspect of the variable qualities of subjective experience and presentation. Mechanical objectivity attempts to display the natural without human intervention, and is concerned not necessarily with "personal idiosyncrasies" but rather with "the subjectivity of scientific and aesthetic judgment, dogmatic system building and anthropomorphism" (Daston & Galison 82). These aspects of subjective representation could be controlled through the application of mechanical consistency and discipline. This introduced a moral quality to the value of objectivity. Control and discipline through mechanical objectivity became a moral imperative of the scientist, atlas maker and artist because it required a disciplining of the ‘unruly’ tendencies of personal judgment, aesthetics and creativity.

Daston and Galison argue that this form of objectivity, present in the mid to late 19th century was distinct from previous desires to stay ‘true to nature’. Early 19th century atlas makers understood their job to be rendering images that were as truthful to nature as possible. Nevertheless, early atlas makers still had to make judgments concerning both what to represent as “nature” and how to best represent it aesthetically. This required atlas makers to make educated decisions: “in order to decide whether an atlas picture is an accurate rendering of nature, the atlas maker must first decide what nature is” (Daston & Galison 86). This is to say, they were responsible for choosing images that they concluded best represented the standard of phenomena in nature. This was difficult because idiosyncrasies even amongst the same species, body parts, plants and so forth are abundant in the natural world, and isolating one or another of these as “natural” was equally idiosyncratic

In nominating these most ‘natural’ depictions, atlas makers in fact sometimes produced representations that were different than the specimens they actually examined. Their images were often composites of different specimens in order to create an ideal image, an image that showed how a specimen *should* look in nature regardless if they had ever witnessed it.

For instance, when Albinus was faced with the task of representing the human skeleton he acknowledged that the human form is diverse, but argued that scientific representations could not be. It was up to him, the atlas maker, to choose and illustrate the best representation of the specimen possible, resulting in the depiction of a ‘perfect’ skeleton whose fidelity to any actual existing skeleton was highly variable.

> "as skeletons differ from one another, not only as to the age, sex, stature and perfection of the bones, but likewise in the marks of strength, beauty and make of the whole; I made choice of one that might discover signs of both strength, and agility; the whole of it elegant, and at the same time not too delicate; so as neither to show juvenile or feminine roundness and slenderness, nor on the contrary an unpolished roughness and clumsiness; in short all the parts of it beautiful and pleasing to the eye. For as I wanted to shew an example of nature, I caused to take it from the best pattern of nature" (Albinus in Daston and Galison 83).

The skeleton Albinus chose to represent the human form, the 'homo perfectus', was a male of medium stature. It was not until Marie-Genevieve-Charlotte Theroux d'Arconville's illustration of the ideal female skeleton in 1759 that an illustration of a female skeleton was published in an atlas. This illustration was known in Germany, but in 1796 Samuel Soemmerring created his version of the female skeleton to wider acclaim and it was praised widely for filling a gap in research (Schiebinger 58). Interestingly, while both representations were deemed objective scientific renderings by their illustrators, the two were very different. D'Arconville's version showed a skeleton in which the skull is shown to be smaller than a male (inaccurate) and the hips significantly broader and the ribcage extremely narrow.

> "The d'Arconville skeleton is, in fact, remarkable for its proportions. The skull is drawn extremely small, the ribs extremely narrow, making the pelvis excessively large. D'Arconville apparently either intended to emphasize the cultural perception that narrow ribs are a mark of femininity, or she chose as the model for her drawing a woman who wore a corset throughout her life" (Schiebinger 59).

Soemmerring however understood his drawing to be a direct compliment to the male skeleton drawn by Albinus. He chose a twenty-year-old woman who had borne a child as his model but also “checked his drawing against the classical statues of the Venus di Medici and Venus of Dresden to achieve a universal representation of woman” (Schiebinger 58). This representation was met with controversy as his illustration was argued to be inaccurate because the proportions of the body were less dramatic than d’Arconville’s and Albinus’s representations. One such critique stated, “Women's rib cage is much smaller than that shown by Soemmerring, because it is well known that women's restricted life style requires that they breathe less vigorous” (Schiebinger 61). What can be deduced from these representations of the ‘objective’ ‘scientific’ and supposedly ‘universal’ skeletons is that they were presented as normative while being laden with ideology and cultural and aesthetic prejudices. While attempting to fill gaps in anatomical research they also worked to reproduce ideals of femininity and masculinity, and to conform to the aesthetic expectations derived from previous representational practices and artefacts. For atlas makers of this period, the goal of their projects was to offer a compendium of standardized objects, meaning that the images were free of the idiosyncrasies present in the objects they were depicting. Because these atlas makers were intent on eliminating the variations found in nature in the name of standardization, their images conflated the ‘essence’ of their objects of study with images reflective of the reigning ideologies of the time.

During this time atlas makers (and their artists) published ideal types or a *typus* that stood to represent entire categories of species, organs, flora types, etc. For these atlas makers, objectivity corrected not so much the idiosyncrasy of individual perspectives and conventions of representation but rather the diversity and variability of nature itself. Eventually however, atlas makers started to become more self-reflexive. Initially, it was considered helpful if illustrators had some general knowledge of the structure of the phenomena they were depicting, not in order to more faithfully reproduce what they saw in nature but instead to be able to more easily represent the *typus*. Regardless, atlas makers kept close watch of illustrators throughout the process, ensuring their vision of the *typus* was being produced. Atlas makers of the late nineteenth century were averse to diversity in representation, but they were not especially concerned that the source of this variation or inconsistency was the subjectivity of their illustrators. Instead, the threat to "objectivity" defined in terms of conformity with typical expectations was verisimilitude, or actual indexical rendering of variable nature. In this respect, producing "objective" representations of natural things required a great deal of intentional mediation by the human subjects producing these images. It was only later that atlas makers would become concerned with the potential distortions and variances produced by the inner subjectivity and interpretive practices of these artists.

> "Owing to the great variation in form presented by some (orchid) species, if the artists render correctly any specimen put in his hands, he is liable to have his veracity called into question, and if any abnormal growth come his way, he had better not be rash enough to represent what may be regarded as impossible by some authority who had made Orchids his speciality. It might tend to upset some favourite theory, or possibility destroy a pet-genus..." (Walter 276)

This address by an illustrator to other would-be illustrators demonstrates the manner in which atlas makers would enforce standardization relative to social norms in the name of veracity. This passage, written in response to the overbearing eye of the atlas maker inadvertently raises the issue of artistic subjectivity in illustration that would become a concern of later atlas makers and other scientists "pointing an accusing finger just where the scientists themselves had begun to suspect their worst enemies lurked, namely within themselves" (Loraine and Daston 96).

This introspection by atlas makers in the middle of the century laid the foundation for an ontological shift in thinking about what subjectivity is and what new methods should be implemented in the name of objectivity. Debates began about whether *typus* depictions were truly the ideal form of representation or whether variations in nature should be represented as they existed. Often the rhetoric suggests that photography (beginning with the daguerreotype) entered the scientific landscape and altered the archival and representational practices in science. Daston and Galison point out however, that this shift was beginning to occur before the invention of photography (98). Photography entered a climate where scientists were already beginning to doubt their personal subjectivity and their choices in representing their objects of study by *typus*. Photography was, nevertheless, instrumental in propelling *mechanical* objectivity into the forefront of scientific ontology and the mechanically produced image as the ideal scientific representation.

Mechanical methods, such a photography, were used to begin policing artists in their production of images. Whereas in previous eras the most talented artists of the time were employed to create images (think Vesalius's *De humani corporis fabrica)* the 'new' objectivity saw artistic expression and artists themselves as a liability to scientific representation (Daston and Galison 99). In an address to the Medical and Physical Society of St. Thomas's Hospital, William Anderson, assistant surgeon, suggested,

> "Although Marcantonio and Vesal, over three hundred years ago, were fortunate enough to secure the aid of men like Leonardo da Vinci and Stephen van Calcar, art of so high an order of excellence is now a luxury that we cannot hope to engage in the service of medicine; but, fortunately, we may console ourselves by the assurance that we do

> not require it. As admirers of the beautiful we must satisfy our aspirations outside the sphere of our professions and we can do this with a facility unknown to our forefathers, but as physicians and surgeons, physiologists and pathologists, our desiderata in artistic reproduction are qualities of lucidity and truth of detail that appertain less to pictorial genius than to scientific intelligence... it will often occurs that the features of an object which possess the greatest significance for men of science are precisely those which the painter might be inclined to disregard on principle, while, on the other hand, an amateur of fair artistic ability, working at his subject with the eye of understanding, may provide use with more useful presentation of anatomical or pathological facts than we could hope to gain from the pencil of Botticelli" (Anderson 29-30)

Here Anderson makes a case against artists due to their favour towards aesthetics over science. For Anderson, it was important to make a clear distinction between fine arts and imagery that was specifically directed towards science. The distorting potential of subjectivity was located inwardly, in the human tendencies toward creativity and aesthetic beauty. For Anderson, as well as many others at the time, there was no room for this in science. As he suggests, aesthetics could be pursued outside of the field of medicine, in a scientist's or physician's leisure time, but imagery within the realm of science need not be visually pleasing; it must be illustrative of the facts. What Anderson hoped was that a distinction between fine art and scientific imagery would serve to place limits on the interpretive latitude of artists.

Photography was one of many tools implemented in the policing of artist's subjectivity. Eventually, atlases began to use photographs almost exclusively, but before this, during the time when extensive use of photographs was financially impractical due to the technological limits of the printing process, they were still implemented in the production stage. One common practice included taking photographs of specimens, which were then selected by the scientific authors of the atlas for use in rendering by illustrators. The photograph would be traced and act as the foundation for the artist's rendering. Often, scientists would supervise the artist's work to safeguard its factualness and ensure there would be no room for interpretation. This concern with interpretation was pivotal in the shift away from composite images. The 'truth to nature' images were presented as the phenomena usually occurred in nature, the scientists argued. It had been a common practice that illustrations would combine elements of different specimens (of the same type) that were amalgamated into a single image by the artist. Even this required selectivity on the part of artists, and soon photography was introduced in the production of composites, which reduced the artist's role in selecting elements and identifying the patterns that would establish representational norms (Daston and Galison 103).

This method never truly took off. Instead, as photography became more commonplace the 'new' understanding of objectivity shifted from presenting a *typus* or standard to representing variation. Photography, a technology of mechanical reproduction, reduced the labour required to produce multiple images. The rationale for selectivity and composition was disrupted, and the meaning of objectivity shifted from conformity to a standardized *typus* to an approximation of the actual diversity of objects themselves, without the intervening influence of a scientist's or artist's determination of normative traits. Under the conditions of mechanical reproduction, such influence reflected the sort of subjectivity – personal, perspectival judgments derived more from the internal preferences than from the external reality they were aiming to depict – that more objective techniques of representation might overcome. The new trend, in keeping up with the shifting understanding of objectivity was to publish photographs of a number of variations of the specimens of a group and instead let the *readers* deduce their own interpretations. The hope was that by offering a range of the same specimen, the reader would be able to discern patterns themselves. The use of photographs (instead of a human artist) seemingly reduced the creative subjectivity and further, it dissolved the subjectivity that came along with a scientist's choice in what the 'truest' representation of a phenomena looked like. Instead, by publishing multiple images of the same type of specimen the potential for subjectivity was located in the reader instead of in the production process of the atlas.

The 'new' objectivity involved self-restraint on the part of scientists and artists and thus became a moralized value. For early atlas makers, scientific knowledge required conformity to standardized norms, and producing images that would achieve this required judgment and selection based on their specialized expertise. As the conditions of reproduction changed human interpretation, judgment and selection came to be seen as subjective practices that undermined the production of objective scientific knowledge. Scientists then were tasked with disciplining their internal subjectivities (judgment, selection, creativity), not only for the sake of 'truthful' science but as a moral imperative. Scientists sometimes sought, not always with success, to discipline these "inner enemies", as Goethe called them, by rules of method, measurement and work discipline, but more often discipline came from within,

> "confronting the "inner enemies" on their own territories. It is internal conflict that imparted to mechanical objectivity its moral tone. Imagination and judgment were suspect not primarily because they were personal traits, but rather because they were "unruly" and required discipline. Moreover, lack of sufficient discipline pointed to character flaws- "self indulgence, impatience partiality for ones one prettiest ideas, sloth even dishonesty- which were best corrected at their source, by assuming the persona of one's own sharpest critic, even in the heat of discovery." (Daston and Galison 118)

Under these conditions, the most moral scientist was the one who was constantly aware of his or her potential 'unruly' traits and took measures to correct them. Strict discipline and self-governance was equated with high moral character and so machines were welcomed as a tool to protect against potential human lapses in discipline. The automation of a machine could not fall prey to such undesirable human traits such as fatigue, inattention, creativity or interpretation. The machine extended beyond human limitations with the promise of producing numerous exact replications, shifting the priority in atlas making from standardization relative to socially or aesthetically-determined norms to more indexical representations of natural variation. While the use of mechanical tools, be it smoked-glass tracings, camera obsurca or photographs, never truly delivered on their promise of indexicality or objectivity without interpretation, it did not stop the atlas makers from claiming these images were 'pure' and due to the mechanization of the production process, they were *authentic* and therefore truthful (Daston and Galison 120).

The photograph soon became the icon of mechanical objectivity achieved without subjective intervention. Particularly with early photography, it would have been difficult to argue that photographic images were more faithful in their representations of "nature" than were hand-produced images. The simplest illustration of this was that early photographs could not capture the range of colours that actually existed in the scenes and objects being represented. This suggests that what established photography as objective in relation to the allegedly greater subjectivity of hand-drawing was not so much its accuracy as its perceived minimization human intervention in the production of images. This is a concept that Sturken and Cartwright coin the myth of photographic truth when they suggest, "despite the subjective aspects of the act of taking a picture, the aura of machine objectivity clings to mechanical and electronic images. All camera generated images...bear the cultural legacy of still photography" (16)

Take for instance the case of microphotography in the 19th century. Microphotography was one of the earliest uses of photography in science and a wonderful example of the authenticity and authority attributed to mechanical representation. Microphotography was introduced 1845 but was not widely used until the 1880s. Manuals were published by promoters of the technique not simply as how-to guides but as promotional materials advocating the scientific value of this technique. According to these authors, the images produced by microphotography were not simply scientific artifacts but could be used as reliable substitutes for the preparations themselves (Breidbach 221). Their foundation was centered on objectivity- particularly that the microphotographs show the "reality seen through the microscope" (222). Because the images were automatically and mechanically produced images, they were implicated in the authority of the 'new' mechanical objectivity. This turn lead the authors of the manual to assert that the microphotographs could be used in place of the slide preparations for further analysis (not simply as documentary evidence).

Interestingly, the objectivity and authenticity attributed to microphotographs relied entirely on highly artificial techniques of magnification. These images were thought to reveal "structural peculiarities which were not discernible by direct observation" (Breidbach 232). Sometimes, however, certain qualities of the images – such as, for example, granularity – were mistakenly assumed to be properties of the slide made visible by the magnification/photography technique, when in fact they were products of the process of reproduction itself.

This indicates the authoritative weight that mechanically produced images and the 'new' objective held: "the faith put into the mechanical reproduction procedure neglected the limitations of the techniques used"(233). Because these granularities were *visible* on the photographs they were *real.* Microphotography was seen as both removed from human subjectivity as well as a tool that could extend beyond the limits of human vision. The possibility of "error" or misrepresentation produced by the mechanical process itself did not register as a potential source of error or misrepresentation in the same way as did the human limits and subjectivity that the technique purportedly overcame.

Furthermore, manual authors (beginning with Robert Koch) argued that the microphotographic images were useful in their ability to standardize practices among scientists and as a means by which scientists could judge each other's work. Microphotographic documentation allowed for a scientist to publish or share his or her images and allowed for his or her descriptions and observations to be critically examined against those images. In this respect, microphotography was not only a method of illustration but also a method that could be used to "control and evaluate the skill of an observer" (Breidbach 242) much like photography was used to police earlier atlas illustrators. The mechanically produced images were interpreted as an objective standard against which scientists could hold each other in their efforts to reduce the influence of subjectivity in their work.

II. Towards a Digital Objectivity

Anne Beaulieu in her work examining the Human Brain Project (HBP) digital atlas responds to Daston and Galison's history of objectivity and suggests that there is a new *digital objectivity* that extends mechanical objectivity but also has its own particular qualities. She echoes Daston and Galison and asserts that digital atlases (particularly the HBP) aim to discern 'type' by offering a number of "comparisons, involving a merger of optics and statistics"(662). For instance, Beaulieu notes that in the instances of schizophrenia and multiple sclerosis the disease as well as the progression of the disease is not necessarily visible in one image (scan).

Using variability maps, the disease is located in relation to the archived images and data; "emphasis is placed on overcoming the individual variations, so that the essence of disease arises"(Beaulieu 663). This follows the same framework that Daston and Galison note. By offering a number of images, including their variations, patterns can be charted and the *essence* of a phenomenon visualized.

Beaulieu takes this a step further and argues that the materiality of the image format plays an important role in understanding what she calls digital objectivity.

> "While the objectivity of the photograph relies on the mechanical objectivity provided by the camera in making the image, the objectivity of scans further involves their digital format; the contents on the image are considered thoroughly quantifiable. The cumulative objectivity of the brain atlas does not reside in imagistic effects, but in the bits of numerical data it contains."(663)

As discussed in the previous chapter, medical scans are different in their materiality and production from photographs, although they often get lumped together. The image of a scan is produced by the mapping of data sets, unlike a photograph that uses wavelengths of light to reproduce what the human eye would see (in theory). Hüppauf and Weingart argue that there is a basic difference between imaging techniques such as ultrasounds or X-ray images and computer generated images (MRI for instance) primarily that the former are artifacts of a "supportive technology enhancing the limited human senses" whereas the latter "creates a visual reality without representation that refers to a theoretically supported potentiality"(13). The consequence of this type of imaging is that it produces a paradox whereby "the more artificial and complex the apparatus and techniques of imaging are, the more natural their products appear" (Hüppauf and Weingart 13). This apparent paradox between the perceived authenticity of images and the increasing artificiality of the means by which they are produced is instructive, but perhaps overstated. It is typical to characterize digital media as enabling a degree of artificiality that differs in kind, and not just degree, from previous technologies of representation. However, in this respect, digital imaging would appear to be part of a trajectory in which perceptions of the artificiality of means are tied to perceptions of enhanced objectivity in the representations they enable. Artificiality here implies minimizing the role of human agency and subjectivity in the production of these images, though it would be difficult to support a claim that these are wholly absent in digital imaging. Human agency, and so subjectivity, persists in relation to these new techniques, they have just been relocated. What is important from the perspective of this chapter is to discern the ways in which digital imaging continues and intensifies the dynamic whereby objectivity is thought to be achieved or enhanced by reducing the role of subjective interpretation in the production and interpretation of images.

The images produced by these computer-imaging devices still require significant interpretation in order to produce meaning. While there is always a level of interpretation in reading visual artifacts, these digital visuals are distinct in that they require "additional input in terms of suppositions regarding the nature of the object; for example, the structure of a tissue and its probable reaction to the magnetic field of the recording process" (Hüppauf and Weingart 13). Whereas a photograph, or an X-ray is recognizable in its visuality, a brain scan requires additional "arithmetic models and algorithms based on medical, statistical, and procedural theories" in order for the image to emerge and become significant (Hüppauf and Weingart 13).

In traditional atlases, such as those described by Daston and Galison, a scientist or physician could refer to the atlas and through the use of heuristics and professional knowledge apply the information from the atlas to the specific specimen or case under inquiry. In the digital brain atlases, this process is automated as "the objectivity built into these also concerns their use; ideally, individual data are to be automatically compared to the representations in the atlas, process also supported by a statistical and quantitative logic" (Hüppauf and Weingart 663). A successful brain atlas, and this can be extended to most digital atlases, is realized in matching the anatomy of individual subjects to the images in the atlas. This step is built into the digital atlas and no longer requires the judgment and discernment of a human observer whose subjectivity would otherwise increase the possibility of error.

Digital images, while implicated in a history of trust in images bring with them a new set of expectations. Martin Kemp suggests that there has always been trust in what he calls naturalistic images (opposed to visual representations of data such as tables or charts). Naturalistic images are implicated in a 'rhetoric of reality' that is amplified in many ways by illustrators of the images. For instance, an anatomical image that includes the use of pins or clamps is a distinctive choice made to lend credence to an article, atlas or so forth. Images produced using digital methods use techniques that further the 'rhetoric of reality' and are amplified by the "rhetoric of instrumental objectivity" (Kemp 345) a notion similar to the "myth of photographic truth" and mechanical objectivity. The aesthetic of the image itself connotes objectivity. When Anderson argued that the images of science no longer required great artists, he was making a distinction about what objectivity should look like- simplicity. Presently, the objective aesthetic is digital and looks 'high-tech':

> "An essential element in the technologically generated image is that it should look high-tech. We know what computer images look like. They have a distinct style, with their own stock ways of rendering surfaces, forms, and space. They have set ways of translating the unseeable into something that can be seen. We can readily recognize an

image that uses the latest technologies, compared to one made twenty years ago. Even if the scientist's visual point could be made with a rudimentary low-tech image, he or she is highly likely to translate it into a presentation that brandishes its high-tech quality. The journal or publisher is unlikely to expect less" (Kemp 346).

Notice that even if the same information could be made in another way or using another tool, methodology or technique of representation, the expectation is that a knowledgeable person will use the highest quality of technical apparatuses available because in this era of digital objectivity authority is tied to complex computer generated images.

III. Visual Representations Become Sites of Analysis

Visual representations in scientific practice are so closely tied to notions of objectivity that in many instances they come to stand in for the phenomena they represent and become sites of analysis themselves. When this happens, often the methods of their creation and the construction of scientific 'fact' are concealed and the representations become naturalized, much in the same way that objectivity as an ideology gets naturalized. Positioning images as epistemic objects demystifies this process, and allows us to begin to ask questions about how these images act on our understanding of the phenomena they come to represent and often times replace.

What is hidden behind the images however are the processes of knowledge production and construction. Bowker and Star describe convergence as the process by which "representations and the world come to resemble each other"(Beaulieu 664). In most classification systems the system itself is hidden and therefore the results are easily assumed to be a simple reflection of what naturally exists. If the negotiations are left behind the scenes, convergence easily occurs images, themselves, get mobilized as objects of knowledge *and* objects of study. All scientific images go through a process of coding and decision making that renders them useful and valuable. Just as scientific knowledge is constructed, so are the images that contribute to and arise from that knowledge. These processes and decisions are executed in a way that images may stand in for the phenomena they represent.

Scientific images, whether they are graphs, scans, photographs or any number of graphical representations are useful not only for their ability to illustrate phenomena, but often they become objects of study themselves. The images turn phenomena or specimens into an easily accessible platform that can be observed and analyzed. Michael Lynch suggests that through a process of 'rendering practices' a scientific phenomena is made visible and representable and in turn, analyzable. Lynch's term draws from Harold Garkinkle's work that states, the process of rendering "describes the transformation of lived-activity into documentary phenomena" (62).

Lynch discusses three rendering methods (marking, constituting graphic space, and normalizing observations). The cumulation of these rendering procedures results in what he calls a 'docile object'. This term is in part reference to Foucault's 'docile bodies' and in part Garfinkel's 'docile record'. Garfinkel's work refers to texts (photographs, tape-recordings, writing etc.) that are documentary works. For Garfinkel, these texts are the 'renderings' of the process that yielded them. The manner in which these texts are produced is central for Garfinkel, and Lynch builds on this with his own explanation of 'docile objects',

> "It is an object that 'behaves' in accordance with a program of normalization. This does not mean that it fails to resist, or that its recalcitrance does not serve to adumbrate its objective news for science. It is to say that, when an object becomes observable, measurable and quantifiable, it has already become *civilized*; the disciplinary

organization of civilization extends its subjection to the object in the very way it makes it knowable. The docile object provides the material template that variously supports or frustrates the operations performed upon it. Its properties become observable-reportable in reference to the practices for revealing them"(44)

By the time a text becomes a text (for the purposes of this thesis a text is a scientific phenomena that becomes represented graphically) it has already been disciplined through processes that makes its visuality valuable. It becomes a text that both reports phenomena and from which analyses can occur to make further observations. The image itself become a site of study and observation and stands in for the phenomena it represents. That being said, if an object does not lend itself readily to the techniques and practices that 'render' a 'civilized' or 'docile object', it does not qualify as scientifically observable, and therefore will either not enter into the knowledge regime or will have be to reconstructed such that it could be (44).

According to Jonathan Crary, the camera offered a representation of the world that was distinctly different from previous representations. The camera transformed the world that an observer encounters, from complex and three dimensional to a flat, series of planar, pixel representations. Thus the images that could be produced using this technique created new standards. To draw upon microphotography again, scientists using this technique were confined to the limits of the technology. These images offered a "highly reduced data landscape in which to represent the objects they wanted to properly understand" (Breidbach 238) and therefore required additional techniques to become standardized to effectively create these images. For instance due to the black and white nature of the photograph, contrast enhancers were effective in augmenting the visibility of the specimens, however "only those colors that could be distinguished properly in various shades of grey are actually represented. Thus, the observer is set apart from the original visual qualities of an object by the nature of the representation technique used” (Breidbach 238). What is seen and analyzed is contingent on representational techniques and practices that are highly constructed. .

Science is a constructive activity and while data does reflect something that is independent of construction on some level it is also not “a mirror of nature arising from an encounter between a rational mind and inherently orderly nature” (Lynch 60). The data and how it is represented is dependent on a complex process between nature, laboratory and researcher. (Evagorou et al. 11). In a similar work by Lynch where he discusses visual displays in scientific publications, he states “in pragmatist, phenomenological, and interpretive sociological traditions, perception is often likened to a filter which selects from, simplifies and orders an initial chaotic world in terms of the perceiver’s projects and interests” (Lynch, “Externalized Retina” 204). As discussed above, at one point, it was the human mind and senses that were idealized as being responsible for filtering the world, experience and knowledge. As Gurwitsch states “whatever *organization* may be found in experience is *bestowed* upon it by the mind working on the 'primordial chaos of sensation” (28).

However, with the onset of mechanical reproduction, the filtering function of the human mind was generalized and externalized in tools and techniques -- whether they are rendering practices as defined by Lynch, coding and highlighting practices as defined by Goodwin--such as medical imaging devices or any other number of techniques that structure and filter the ‘natural’ world and “take the place of ‘mind’ as the filter, serving to reduce phenomena of study into manageable data” (Lynch “Externalized Retina” 204).

Human experience and the ‘mind’ are replaced with tools, instruments and processes that order the natural world and it is from these processes our objects of study emerge. This is a notion echoed by Latour when he suggests “knowledge, it seems, does not reside in the face-to-face confrontation of a mind with an object, any more than reference designates a thing by means of a sentence verified by that thing”(69). In Latour’s ethnographic study of soil sampling in the Amazon forest, he studies the processes by which knowledge is produced, recorded and analyzed for scientific and research aims. For him, knowledge resides in a chain of representations. There is never a direct relationship between the mind and object of study for every interaction is mediated by language, images or processes. These representations come to replace the object,

> “the combination of discussion, know-how, and physical manipulation allows for the extraction of a calibrated qualification of texture that can immediately replace, in the notebook, the soil that can now be thrown away. A word replaces a thing while conserving a trait that defines it” (63).

For Latour, the process of classification allows for the erasure of the original object. In his case study, sand gets replaced by a set of classifying words in a notebook. These words then stand in for the sample and the sample can be disposed of with the reassurance that the significant traits of the object are preserved. These representations are then re-represented in a chain of knowledge production. For instance, words in a notebook become a diagram.

Vision as a process requires more than the sensory action of looking. There exists a relationship between the ability to ‘see’ an object and at the same time to identify it linguistically. Amann and Centina in their study within a DNA laboratory, problematize this somewhat by posing the question “ what if these objects are, as they appear to be in science, *visually flexible phenomena* whose boundaries, extension and identifying details are themselves at stake?” (87). They suggest that the issue for scientists is not “the equivocality of ostension or the impossibility of being certain that a translation into language is correct” (87), instead the problem is the ability to come up with and solidify a translation in the first place, that is, the process of evidence fixation. Evidence fixation occurs when phenomena are translated into representations. As Hüppauf and Weingart suggest, “the new computer generated images are arbitrary in a way comparable to the arbitrariness of linguistic signs. They visualize theories and models of the invisible”(14).

Keeping with Latour’s case study, representations such as a diagram come to stand in for a phenomena, relaying crucial information that they don't necessarily resemble in a traditional sense. A diagram or a chart does not resemble sand or clay, they are “not realistic; it does not resemble anything. It does *more* than resemble. *It takes the place of the original situation*...”(67). At each stage of representation there are losses (reductions) and gains (amplifications). While representing sand in a diagram reduces its physical likeness it amplifies its physical properties in a manner than can be analyzed. Its relevant properties are recorded and becomes a site from which further knowledge is produced; “constructing a phenomenon in successive layers renders it more and more real” (Latour 76). Terri Kapsalis echoes this in his study of gynecology and representation stating that “the drawings, accompanied by their labels create an orderly hyperreal, a real better than reality, in many ways viewed as more accurate than the photograph”(97). This suggestion of a ‘realer’ reality is a reality that bends to our naturalized organizational practices. These versions of the ‘truth’ are ‘better’ because they are already classified, ordered and in a sense tamed. In these instances, “nature-the nature that is the object of knowledge -is *nature humanized,* the world of objects produced through human intervention” (Lenoir 204). ‘Objective’ scientific knowledge is *created.* It is knowledge that has been filtered and manufactured, mediated by our social and cultural positioning as well as our material resources and organizational practices. The instruments we have available, the experimentation techniques we have developed are all ways in which we harness and construct nature.

For this reason scientific images should be looked at in terms of their value as epistemic objects. Images in this context are significant not only for what they communicate but as objects of scientific knowledge and procedure themselves. Graphical representations are often looked at in terms of the information they convey. Looking at them in terms of their materiality and their form of representation illuminates the practices of their formation. This is significant in that it demonstrates how images are not only serviceable as tools in scientific knowledge but crucial in how we know what we know. If we acknowledge that the processes in place to create visuals, and that the materiality of the visual representations themselves are central to the scientific knowledge we have, we can understand them as epistemic objects as well as gatekeepers of knowledge. What we know is contingent on *how* we can know.

Take for instance digital atlases which are in mode in the current scientific climate. Talking about the Human Brain Project Beaulieu asserts,

> "These atlases reinforce the importance of certain features...While provisions are made for ensuring the translatability of many types of data, including new dimensions along the way may not prove feasible, leading either to the abandonment of the database, or to reinforcing the elements that are included as those most important in understanding normality and disease" (669).

Because the database is set up to reveal certain types of information it in effect hides others, or makes including new dimensions difficult. Because the atlas is used as an object of study itself, further knowledge production is based on the parameters set by the images in the data base. This has the potential to shape the types of questions that are being asked and the research that is being conducted. Research questions may be guided by what is knowable based on these atlases, and what is taken for granted is that these atlases and images only show a partial story. There exists information not found in these images because they were designed to illustrate specific factors. The ‘missing’ information is either ‘missing’ in that uncovering it would involve a new process and perhaps a new organization of the database or because the information cannot be known using the imaging techniques and technology currently available.

If an object or phenomena is not compliant or compatible with a program, method or technology its properties would not be (completely) ‘scientifically’ observable. What we know is dependent on the frameworks we have for knowing, and in many cases visual confirmation and representation of phenomena is held in high esteem in scientific communities - seeing is believing. Lucy Suchman synthesizes the current social science literature concerning representational devices and scientific practice when she states

> “Several premises underlie the study of the relation of such devices to scientific practice. First, that it is through these devices that the regularity, reproducibility and objectivity both of phenomena and of the methods by which they are found are established. Second, that representational devices have a systematic but necessarily contingent and *ad hoc* relation to scientific practices. And third, that representational technologies are central to how scientific work gets done” (304)

If representational technologies are central to scientific knowledge and the representations they render are considered the objective standard by which knowledge gets shared, then to ignore the processes by which these technologies come to create representations is problematic. These processes are important in that they illuminate that scientific visuals are implicated in a complex network of procedures, but also that what we know is dependent on what we can identify through the procedures and technologies we have.

Illuminating the shifting meanings of objectivity works to display that objectivity is not fixed and is an ideal constantly in flux. Chronicling the shift between truth to nature, *typus* and mechanical and digital objectivity shows how the subjective has been located in the uncontrollable – at one point, the uncontrollable variability of the natural world and, later, the uncontrollable subjectivity of individuals. It was in relation to this latter contingency that it became apparent that striving for objectivity was not only a value in science but a moral imperative. Restraint became conflated with moral dignity and mechanical and automation apparatuses became tools to be used in order to ensure that the immoral 'inner enemies' of human subjectivity were kept in check. Further, these mechanical tools, implicated in authority, objectivity and truthfulness, began to be hailed as a standardization mechanism, as well as a way to police, and hold accountable other scientists and their findings. By demystifying objectivity and positioning it as a value, not as a fact, we can see how there is space for ideology to be cloaked under a veil of objectivity, as was present in the first illustrations of human skeletons.

Examining objectivity in this respect illuminates how images, particularly those implicated in mechanical and digital objectivity become situated as authentic truthful and 'objective'. Because of this they are not only artifacts but sites of analysis themselves. They come to stand in for the phenomena they represent while the methodologies and construction of their production is often erased. This works to naturalize their authority. Illuminating the construction and methodology of the creation of visuals and treating scientific graphical representations as epistemic objects works to dispel the connotations of naturalism. Furthermore, discussing science and visual scientific renderings as a constructive activity works to demystify scientific imagery and allows us to critically approach the perceived authority of mechanically and digitally produced images.

Going forward, this sets a foundation from which closer analysis of how these representations in turn act on our understanding of the body and health. As Ian Hacking suggests, “seeing is intervening” and is an act with consequences. The next chapter will take the somewhat broad concepts discussed in this chapter and localize them within the context of Magnetic Resonance Imaging examinations and scans and look at the way in which things like morality and ideology are implicated in the technological process and discourse and how the images that are produced act on the body it represents, our conceptualization of the body more broadly and by extension our conceptualization of disease, healing and intervention.

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III

Producing the Body

"The assumption that seeing is believing makes us susceptible to visual deceptions"

- Kathleen Hall Jamieson

It is common discourse that medical technologies such as the MRI machine have the capacity to reveal the interiority of the body in an objective photographic manner, as if looking into the body through a transparent window. Along with these assumptions comes speculation that if we can 'see' illness with these technologies it is a small step to then be able to effectively treat and cure pathologies beneath the skin. While imaging technologies such as the MRI certainly offer extensive information about certain aspects of the human body, focusing on their supposed ability to render the body transparent overshadows significant additional impacts these technologies and procedures have. This chapter has two objectives. First, it will use themes raised in previous chapters regarding representation, visuality and objectivity, and focus them specifically within the context of MRI technologies and examinations. Second, this chapter will look at the ways the use, proliferation and dissemination of these images, both in medical contexts and beyond, influence how we come to know and conceive of our lived bodies and how we understand illness and health. The aim of this chapter is to complicate the notions that MRI and other medical imaging technologies produce transparency and to expose the embedded ideologies that link mechanical reproduction with unmediated objectivity as well as the equation of visual reproduction with authoritative reality.

I. Neutrality of the MRI

As discussed in Chapter 2, we are 'visually trusting beings' and have an affinity towards “trusting images of things we have never seen and are unlikely to see” (Kemp 345). Previously, this work discussed the myth of photographic truth and the rhetoric of instrumental objectivity. Images, particularly those created by machines, are strongly associated with truthfulness, for they are seemingly created without human intervention. Because the processes of production are often hidden and the technologies themselves are effectively ‘black boxed’, “an image produced by the latest high-tech gadget, whether a perspective machine in the Renaissance, a *camera lucida* in the nineteenth century, or an fMRI scan in our time, promises levels of disinterested precision beyond that of even the most scrupulous human investigator” (Kemp 334). Automation and mechanical reproduction generate a sense of mechanical objectivity, defined as insulation from the distorting influence of human subjectivity. Digital objectivity extends the notions of mechanical objectivity and adds a quantitative element. Digital images are deemed ‘objective’ not only because they are produced by machines, but also because the images are data sets made up of immense sets of numerical data points processed by algorithms. Part of this new ‘objectivity’ requires that the image have the aesthetic of the latest technology; “we can readily recognize an image that uses the latest technologies, compared to one made twenty years ago”(Kemp 346). Images are not only caught up in the rhetoric of authenticity attributed to automation but also the rhetoric that conflates technological ‘progress’ with authenticity.

Images produced by way of an MRI examination provide an interesting example of digital objectivity in action. While they bear the aesthetic marks of digital media, the images produced by an MRI machine look rather unlike anything the layperson may recognize. They require a “decodifying gaze” (Ortaga 42) or accompanied language in order to make sense of the image. The rhetoric of transparency that surrounds MRI images would suggest that their subjects become clearer under its ‘gaze’ but, despite popular discourse, there is no direct legibility. These images require an expert's interpretation -a practice of interpretation which has been taught and disciplined. This complicates traditional notions of objectivity that suggest that objectivity means to be removed from human mediation.

The MRI remains "surrounded by a discourse about their immediacy, by the rhetoric of self evidence that accompanied the rise of mechanical objectivity in the mid-19th century" (Ortega 45). While 'objectivity' often connotes resistance to human (i.e., subjective) qualities, new medical visualizing technologies in fact require an extensive amount of human interpretation and interaction. The images produced by an MRI for instance, "do not speak for themselves. They are media without a message but with the potential to become a message, requiring additional input in terms of suppositions regarding the nature of the object" (Hüppauf and Weingart 13). Although these technologies represent the most 'advanced' contemporary medical apparatuses they remain archaic in the sense that they require significant interpretation and programming.

> "In order for an image to emerge, arithmetic models and algorithms based on medical, statistical, and procedural theories is necessary. The resulting images appear surprisingly naturalistic and this impression leads to an underestimation of the unification of technical procedures, physiological and mathematical models, and the iconic conventions, which may produce a picture of realistic resemblance, but under adverse circumstances, an imprecise or plain false image"(Hüppauf and Weingart 13).

In the instance of previous visualization techniques in medicine, images augmented the senses and made visible what was invisible. Analog X-rays for instance, produce images of the human skeleton that are continuous with the physical reality of the anatomy they represent. Digitally generated images - MRI included-- "create a visual reality without representation that refers to a theoretically supported potentiality" (Hüppauf and Weingart 13). These images are arbitrary in the same way that Saussure suggests the relationship between signifier and signified is arbitrary in linguistic signs. This does not mean that digital images are not 'real' – it just means that claims about their authenticity or objectivity which are grounded in assumptions about unmediated connection between the images and what they depict are difficult to sustain.

In his investigation of MRI scans and work practices, Amit Prasad discusses the question of the objectivity of MRI produced images and suggests that these images are implicated in a new visual regime he calls 'cyborg visuality'. He suggests that while there are similarities between the MRI scans and previous imaging forms, these new images are a radical break that significantly "alters the mechanics and architecture of the medical gaze, shifting it to a new visual regime that should appropriately be called cyborg visuality" (292). These images, which are not images in the traditional sense, but rather image data that are "computer generated visual reconfigurations of physical data" are "once or twice removed from reality" (292). This echoes Latour's previously discussed assertion that classification in the form of diagrams, images or words allows for the erasure of the 'original' object.

This is significant in that, while the data are presented in the form of images, oftentimes the image is only possible because it originates in digitized data that can be manipulated in particular ways to generate a legible image. Whereas other imaging methods use a singular parameter to fix an image, there are multiple possible parameters that can be attached in producing MR images. If there is pathology that isn't immediately visualized due to, for instance, the volume of fat cells in the patient, the radiologist or physician can request that the technique be altered to suppress the signals emanating from the fat therefore excluding it from the image so it does not obscure the pathology that is the object of the scan (Prasad 298). Again, human interaction with the technology is vital for creating an image and for deciding what type of image needs to be produced. The medical gaze is extended further, complicating simplistic notions that medical imaging technologies are free from human subjectivity and simply correspond immediately to the physical properties of their objects

As discussed in Chapter 2, images created by MRI must be disciplined and fashioned into a norm (usually by being included in an atlas) before they can be useful in diagnostic procedures. That being said, even with the opportunity for automated cross referentiality, absolute certainty in the predictions and diagnoses based on the images is impossible. There is the issue of individual judgment in reading and interpreting the information in the images, but beyond that, the information and possibility for the detection of pathology is nonetheless contingent on the base of knowledge about illness and the body available to attending technicians and physicians (Prasad 300). Medical imaging is a useful tool, and can surely offer valuable insight, but it can only relay information that a physician or radiologist has been trained to read. It displays information about the interiority of the body but what is identified is contingent on what is already known about the body in science and medicine and how well a physician can leverage this knowledge.

Furthermore, ‘social’ information is embedded in a physician or radiologist's gaze. Sex, age and race are all factors to consider in an examination. For instance, when scanning for a brain tumor a radiologist’s technique would be different for a patient over 35, when chances of having a brain tumor are higher. Again, the MRI does not act as a universal window into every body. The atlas images that serve as a foundation for a radiologist’s knowledge are representative of averaged variations in society, suggesting that the “cross referential network through which pathology is fixed is open-ended and the closure that is achieved is always conditional, limited, and exists so long as it dovetails with other findings and available data" (Prasad 300). For this reason, cyborg visuality in the case of MRI has a 'bifocal vision' and while rhetorical practices suggest an MRI's objectivity derives from its automation and distance from human interpretation, it is highly dependent on human cross referential networks and interpretation. For an image to be legible there are a number of interpretations and choices that have to be made, "the result thus involves a balance between reproduction and construction, between an ideal of objectivity and interventions aimed at facilitating the decoding of the images" (Ortega 46).

II. The Flexible Body

As Sarah Nettleton quite fittingly states, "the more sophisticated our medical, technological and scientific knowledge of bodies becomes the more uncertain we are as to what the body actually is" (43). Contemporaneously there are a myriad of tools and technologies that have the capacity to record and inform us about any number of bodily ailments or uncertainties and because of this, the distinction between the 'natural' body and the 'social' body is becoming blurred. Prosthetics have spurred academic debates about 'true' or 'pure' bodies and cyborg bodies. Techniques and technologies that assist in the conception of life have blurred boundaries as to when life begins. Imaging technologies give us insight into diseases previously not visualizable. With this capacity for new information, what was once fact regarding bodies, life, death and illness are becoming increasingly complex (Nettleton). For this reason, social and ethical discussions of the body have become prominent in sociological works.

One such approach is to evaluate the ways, and the extent to which, bodies are regulated by social institutions and more specifically within a medical context. Bryan Turner's work is significant in this field. He suggests that we currently live in what he calls, a 'somatic' society. Turner notes that in advanced industrial societies the body is no longer the 'productive body', "whereas most social scientists are concerned to understand leisure as a mechanism of body production in consumer society, it seems to me that the body is being increasingly experienced, discussed and represented as a limit and as a brake on growth" (11).

One way this limit is discussed is in relation to the 'burden of dependency' of aging bodies in advanced capitalism. Aging bodies are discussed in terms of their implications on the welfare system. This creates a foundation for the legitimacy of extended medical surveillance on populations in contemporary society (11). For Turner the 'somatic society' refers to a society in which the body is central to cultural and political activity.

> "The earlier ideas of the leisure society, the consumer society or the post industrial society expressed certain optimism or confidence about the future. These concepts have been replaced by a more nervous paradigm of disorganization, especially in the neo-Marxist view of disorganized capitalism or the postmodern vision of the hyper-real society... In postmodern debates, the body acquires the aura of a special nostalgia in the world of risk, uncertainty and disorganization"(12).

While Turner's book is somewhat dated, his premise still rings true. Contemporary society is less concerned with a body's ability to produce, and rather the focus has shifted to regulating bodies in a time that seems unpredictable, increasingly risky and 'out of joint'. Our conceptions of risk have shifted and our "metaphors of disorder perhaps reflect our consciousness that death visits our bodies, not through acts of overt violent, but secretly through cancerous growths, silent viruses and humiliating strokes" (Turner 12) and therefore in the somatic society regulation and medical surveillance is central. The somatic society is concerned with 'closing up bodies' and this type of regulation can be observed in safe sex education, clean needle exchanges (Turner 13) and of course the widespread use of imaging technologies which offer us opportunities to 'see' these 'silent killers' and regulate illness.

Turner's somatic society parallels notions of neoliberal governance, which is "focused on the privatization, and deregulation of the state, while simultaneously inducing citizens and corporations to regulate and govern themselves" (Whitson 527). Under this tradition the body becomes a site where self-regulation and ensuring one's own health is so heavily encouraged that it becomes an expectation and a societal norm. Human bodies then come to be understood as endlessly transformational, "requiring engaging in work on the self and reflexive self-monitoring as part of performing selfhood and embodiment" (Lupton 203). 'Technologies of the self' (Foucault) or 'reflexive biographies' (Beck), speak to this expectation that 'good' citizens will partake in practices that improve and extend their lives, health and wellbeing. Often central to improving one's health in this respect is monitoring one's body and seeking out information that can be leveraged into good health practices. These expectations and actions result in a notion that the body is always 'unfinished' and can always be improved, monitored and assessed. Historically, the body was a fixed part of 'nature', rarely a sight of intentional human intervention (Giddens 217). However, under modernity's reflexive inclination,

> " the body itself has become emancipated- the conduction for its reflexive restructuring. Once thought to be the locus of the soul, then the center of dark, perverse needs, the body has become fully available to be 'worked upon' by the influences of high modernity. As a result of these processes, its boundaries have altered. It has, as it were, a thoroughly permeable 'outer layer' through which the reflexive project of the self and externally formed abstract systems routinely enter. In the conceptual space between these, we find

> more and more guidebooks and practical manuals to do with health, diet, appearance, exercise, lovemaking and many other things" (Giddens 218)

Under these conditions, self-preservation and surveillance is imperative. The body seems more uncertain and certainly less fixed than it was historically and because of this it is approached as a pliable, malleable site for improvement and alteration. Sarah Nettleton draws from Emily Martin's study about beliefs regarding bodily immune systems in North America and suggests that contemporary societies value flexibility and are characterized by notions of change and adaptability (50). According to Martin, the healthy immune system is often linked with flexibility in common discourse. According to her ethnographic study that included patient observation, interviews and informal exchanges, many patients believe that an effective immune system is one that is adaptable and flexible and that maintaining a healthy immune system is internalized as "common currency" (Nettleton 50). Martin suggests that flexibility is an ideological value that exists in broader neoliberalist culture and has been applied to the ways in which we conceive of our bodies as well.

> "Arising as a trait to be cherished and cultivated, from corporations and city governments to credit cards and shoes, flexibility is an object of desire for nearly everyone's personality, body and organization. Flexibility has also become a powerful commodity, something scarce and highly valued..." (Martin xvii)

The way we perceive and interact with our bodies is therefore socially contingent and is linked closely to prevailing, naturalized ideologies. In a society where self-monitoring and the capacity for an abundance of information regarding the self is prevalent, accessing and utilizing this information becomes expected. As Nettleton suggests, "how we experience our bodies is invariably social, and one of the central thrusts of modern times is that we feel compelled to work at creating a flexible and therefore adaptable and socially acceptable body" (50).

The MRI as a communicative medical tool is emblematic of this neoliberal condition. The discourse surrounding MRI suggests that it offers transparency and an unmediated look into the inner body. Transparency seemingly offers additional, significant information about the parts of the body that were previously inaccessible and therefore uncontrollable.

> "The notion of transparency (Dijk 2005) interplays with body presence/absence, one of the main hallmarks of the health and wellbeing oriented, consumer society. Transparency comes into play as medical information and technologies show an increasingly trend to support inner body examination; plus, it is validated by increasing self-observation, self diagnosis or self-medication as a way for the layman to access body signs and effectively act inside it" (Machado Gomes 85)

Examining the body with imaging technologies seems natural and even socially and personally responsible in the present context. Moreover, with added potential for information garnered from devices that seemingly peer into the body, using these technologies as part of an examination becomes expected. It is also widely assumed that by accessing these images, the body can be cured of ailments hiding beneath the skin, and that it is a small step from visualization to treatment. The use of MRI and the discourses surrounding them is both a result of the current neoliberal culture of self-surveillance as well as a tool that gets leveraged (in both clinical settings and public discourse) as a way to 'fix' the internal self. This understanding of imaging technologies suggests that the body is flexile and malleable so long as we can 'see' it. The limits of corporeality are being pushed and extended both in medical practice and rhetorical practices and notions of the body as fixed are no longer the reigning ideology. Instead, flexibility and pliability are central beliefs surrounding the lived body as well as commonly held values.

III. Moral Implications

Chapter 2 discussed the interplay between subjectivity and morality. Although the meaning of subjectivity has transformed over time, morality has always been closely tied to subjectivity. With the advent of mechanical objectivity, human interpretations in the reproduction of images were seen as not only subjective and therefore less trustworthy than images rendered from automation, but also potentially immoral. Subjective human capacities and inclinations such as creativity or aesthetics were seen as unruly traits that had no place in science and, therefore, the most moral scientist was the one who overcame these traits by using mechanical tools.

Moral imperatives become apparent again when we begin to look at the somatic or neoliberal understanding of the body. Under this system, 'good' citizens are responsible for the regulation of their own bodies, gathering information and taking proactive steps to ensure their health and wellbeing. Doing so is expected and therefore becomes conflated with 'good' moral character. Conversely, failure to tend to one's body in ways that are socially acceptable is deemed to be a moral failing.

Foucault writes at length about the ways in which bodies are regulated and monitored within a disciplinary society. Foucault suggests disciplinary power resides in the bodies of individual citizens, as distinct from the sovereign power that resides in the leadership of the state. By way of norms and conventions, bodies can become self regulated by their conformation to certain social and even governmental expectations and therefore exert self discipline at all times. Disciplinary power is found at the individual level, by regulating individual bodies and at the broader population level by monitoring populations as a whole in institutional settings (hospitals, schools, etc.).

> " it is within such institutions that knowledge of bodies is produced. For example, the observation of bodies in prisons yielded a body of knowledge we now know as criminology and the observation of bodies in hospitals contributed o medical science. In fact it was the discourse of pathological medicine in the eighteenth century which formed the basis of the bodies in western society that we have come to be familiar with today. The body, Foucault argued, is a fabrication which is contingent upon its discursive context" (Nettleton 46).

This argument is two-fold. First, as evidenced in the multiple approaches to understanding the body in different institutions, there is no a priori body that exists outside of social or discursive contexts. When the MRI is discussed as being a transparent method to look at the body this assumes that there is an a priori body that exists universally, free from mediation and context. Second, in this context of individualized discipline, citizens are made responsible for their own bodies and behavior. Certain codes or mores become naturalized and form the moral basis of disciplinary self-regulation.

This is foundational for Turner's later assessment that the medicalization of society and the regulation of bodies in this way has taken on a moral function akin to religion. He suggests that as society has become increasingly secularized, medicalization "occupies the space left by the erosion of religion" and that the moral functions of medicine are "typically disguised and they are ultimately legitimized by an appeal to scientific rather than religious authority" (22). Just as God sees into individual souls so they might be disciplined, corrected or restored, the MRI sees into individual bodies in order to accomplish the same.

In serving this function, MRI technologies assume the character of an authoritative scientific icon. Using the latest medical tool available becomes a moral imperative both for a patient to seek out and for a doctor to offer. If scientific authority has come to replace religious authority, then keeping up with scientific advancements is crucial in the quest for good citizenship and moral character. The progress of science and technology is crucial. The MRI, as a highly technical imaging device, is implicated in narratives of unmediated access to the body and transparency, and becomes a tool a responsible doctor utilizes as part of an examination.

> " Clinical examinations and other 'low-tech tools such as stethoscopes, touch, and patient histories are always positioned as subjective and inaccurate sources of knowledge, while the MRI or medical image represents a better, more objective, neutral technique. Furthermore, the clinical examination is labeled as (or implied to be) 'primitive' in contrast to an image that is taken as a sign of 'progress' (Joyce 441).

The MRI represents technological progress and in a society where progress is respected and the latest scientific methods are authoritative, the best available care comes to mean care that uses all possible and progressive resources. As one patient so aptly put it, "I think about someone tapping on your stomach rather than having this image that essentially slices you in half so you can see inside'... 'its like the caveman to the year 2000' (Joyce 442)

This rhetoric positions vision higher on the authoritative hierarchy of knowledge (over sound and touch) as well as implying that not to use the latest technology would be negligent, and that the information gathered from a physical examination is less valuable. Progress as a value as well as the suggestion that MRI technology offers an opportunity to 'discover' the inner body, a body "that exists outside of language and human actions" (Joyce 441) in a certain and definitive way, results in an assumption that good, effective and moral care is care that uses this device. This is however not always the case. A study conducted in Ontario found that while expensive imaging tests are often administered as the initial testing for coronary artery disease

(CAD), older and less expensive, non-imaging testing such as graded exercise tests (GXT) are just as effective in diagnosing CAD (Roifman et al.). 'High-tech' machinery are deeply implicated in discourses that equate them with progress and morality and visualization technologies as authoritative 'truth tellers'. MRI technology fits neatly into these cultural beliefs about images and new technology and these perceptions create a tendency for the value of MRI examinations to be overestimated.

IV. The Clickable Body

MRI examinations fit into cultural tropes about accessibility and ease of information in the digital age, and this has implications for how we understand illness and the body. MacGregor Wise talks about a 'swarm of screens,' that is, a society which individuals are constantly connected, where screens are "fixed, and immobilized into our ambient architecture" (212). He discusses the extent to which screens have become a part of daily life embedded into architecture in our homes, malls, restaurants, waiting rooms while also being brought with us in our pockets. He suggests that we live in, what he calls a 'Clickable World',

> "Simply put, the Clickable World is a social imaginary that posits that the ways that one navigates online social spaces is becoming how one navigates one's "real" life The world appears malleable, available, interactive and information-filled. The Clickable World is where one approaches the everyday environment as being analogous to navigating the Web on a computer screen: just click around for further information. There is a presumption of agency here in this imaginary, human agency over the environment- the world is at hand, in control" (Wise 213).

In this 'Clickable World' information is seemingly endless and is always within reach- at the ends of our fingertips procured simply by clicking through a computer or smartphone. In this social imaginary, we relate to our environment in much the same way we relate to our devices. Because information seems so easily accessible our environments appear navigable and under our direct control. Our bodies then, become something we assume can be easily navigable as well.

Large quantities of information regarding human bodies are digitally recorded. Everything from census reports to fit bits, to calorie diary apps become prosthetics of digitized bodies. In a world were we are encouraged to track the 'self,' be engaged and develop 'self knowledge,' as well as being a part of the 'Clickable World,' our bodies are increasingly quantified. As Jennifer Whitson notes, "technologies such as the Fitbit or SuperBetter enable us to measure, chart, and quantify what was previously unquantifiable and also allow us to transmit and share what was previously private" (346). Aspects of our biological functions such as steps walked, calories eaten or emotional states that were previously intimate aspects of our physical bodies are becoming digitized and publicized. Deborah Lupton furthers this notion and suggests not only are these aspects of the 'self' being tracked and made public but they are being assessed and become a site for intervention.

> "Digital representations of bodies and digital data on many aspects of embodiment are generated from the various sites, devices and spaces which with individuals interact daily: the transactional data produced via routine encounters with surveillance cameras in public spaces, sensors or online websites, platforms and search engines or from the content that people upload voluntarily to social media sites or collect on themselves using self-tracking devices. These technologies create and recreate certain types of digital data assemblages which can then be scrutinized, monitored and used for various purposes,

including intervention" (Lupton 3).

In this assemblage, public self-tracking and intervention are normalized aspects of daily life. Digital bodies and digital information about bodily functions are a natural progression of neoliberal individualized monitoring.

The Visible Human Project (VHP) is an excellent example of the Clickable World assemblage working to produce the body in a way that seems knowable, navigable and clickable. The VHP is an online digital resource that aims to be a compendium of the human body and the creation "of complete, anatomically detailed, three-dimensional representations of the normal male and female human bodies" (US National Library of Medicine). This database recreates the human body through the use of various imaging techniques (CT, MRI, cryosection images) and offers it up as a universal tool to be used for educational purposes. What is interesting about these images however is,

> "The VHP visually replicates bodily organisation without presenting any of its material intransigence. The interior flesh can be visually traversed in any fashion, the point of view can literally move through the virtual flesh at will, constituting flesh as pure spectacle, without density, recalcitrance, material consistency or self-enclosure. Hence, interior structures like the skeleton, the colon, the oesophagus, and the arteries can be navigated using 'flythrough' software, which visualises the data 'as if the viewer's eyes were freely mobile inside..." (Hong et al. 72)

This use of software to 'flythrough' or click through parts of the human body is familiar within the Clickable World assemblage. The VHP presents the body as something that can be completely indexed and transversed as easily as clicking through a webpage. The point of view of driving through the body as if in a 'space ship' is also interesting in that the perspective infers the viewer's agency over the body under inspection. In this respect, digital data of our bodies have material consequences for the way people act on and conceive of their lived bodies and bodies more generally. Lupton suggests,

> "Our bodies now engage routinely with digital technologies to the extent that it is taken-for-granted. It is now frequently argued that online and offline selves cannot be distinguished from each other any longer, given the pervasiveness and ubiquity of online participation. Instead categories of flesh, identity and technology are porous and intermeshed... Our bodies are digital data assemblages" (3)

Digital data sets have become so commercialized that the difference between big data and small data is being blurred as well as the distinction between what is private and public (Lupton 4). This is playing out on our conception of bodies as well. Food diary apps make calorie counting public information. Fitbits quantify the movements a body makes in day. And the VHP offers up the body as universal, knowable and navigable in much the same way we use apps in our day-to-day lives.

In this social imaginary, our environment is controllable in our hands. This has had significant implications for our understanding and experience of the human body. In clinical diagnostic settings, computer screens and digital images have become the dominate medium for framing the body and medical imaging devices are understood to be faithful representations of otherwise hidden physical conditions. Medical imaging scans, digital 'fly-throughs' of anatomical systems and virtual dissection are technologies that have influenced common notions of reality, destabilizing the distinction between actual and virtual space. Using these tools it would seem that the body is as knowable and navigable as our online environments, "any dichotomy that categorically pairs offline with real, and online with unreal, misdiagnoses the reality of contemporary experience" (Barney 31).

V. Digital Scans Stand in for Physical Body

The Clickable Body suggests that the body is an entity that is malleable and transparent with the right tools. It also infers that the digital representations of bodies are as authoritative, if not more, than the lived 'real' body. These representations come to stand in for the physical body as a site of knowledge and, as Nettleton claims "the body has disappeared, there is no distinction between bodies and the images of bodies... It is the image of the body which now forms the basis of medical care" (50). This is distinctly different from the patient's lived body being the primary site of investigation, authority and basis of medical examination.

Chapter 2 discussed the tendency for images within science to become sites of analysis themselves, often taking the place of the phenomena they initially served to represent. This is especially true for diagnostic images. The bulk of diagnostic work takes place away from the physical patient. In the case of an MRI examination, the patient is placed inside of a machine, and in a separate room a technologist produces a scan (image). The scan is then interpreted without reference to the physical body. While notes on the patient are sometimes consulted along with a scan, the diagnostic work and conclusions are often physically removed from the patient; "the image on the screen becomes the 'true' patient, of which the bedridden body is an imperfect replicant, less worthy of attention. In the screens' simulations our initial certainty of the real (the body) becomes lost in hyperreal images that are better than the real body"(Nettleton 50). This becomes problematic specifically in cases where illness or symptoms are felt experiences that are not easily visualizable, even with the most advanced imaging equipment. In a study that looked at patients with chronic back pain, often what patients expressed was frustration that their pain could not be diagnosed because it could not be ‘seen’. One patient is quoted in stating that doctors,

> “Try to tell you backaches are psychosomatic and your back couldn't be hurting, there’s nothing, no reason for it to hurt. X-rays don’t show anything and you don’t really have a backache. Oh yes I do, yes I do ... but back aches are hard to see. Unless there’s something that’s a visible thing. Its kind of your word against who’s looking.” (Rhodes et al. 191)

This patient’s frustration stems from the fact that their own body and their physical symptoms seem to be taking a back seat to the more ‘legitimate’ source of knowledge- an imaging technology. In this statement, the patient expresses concern that it is their personal claims and physical experience against ‘who is looking.’ This can be extended to suggest that it is not only who is looking but *how* they are looking. If it cannot be seen with the imaging technology, it is considered a psychosomatic experience and somehow less ‘real’. There is a disconnect between the lived body as one experiences it, and the body that is observed, described and understood by medical experts and their tools.

Speaking specifically about MRIs, Joyce suggests that the technology itself is seen as an agent and portrayed as the expert with a superior way of knowing the body. This, coupled with the rhetorical practices of speaking about MRI technologies as if they are able to reveal the inner body in a transparent way “produce a construction of MRI in which the image and the physical body are seen as interchangeable... the MRI machine is made to speak and act for itself” (Joyce 438). Perceptions of images as authoritative and transparent reinforce the privilege of the image in diagnostic settings and excludes other factors such as interpretation. This has, however, additional consequences such as erasing the body as it is lived and experienced and in some cases, silencing or minimizing a patients' sentience.

Common rhetorics that position MRI and other medical imaging procedures as transparent and authoritative then are not only common amongst the lay person or in popular culture but are reinforced by medical experts in the language they employ when discussing the machines themselves. Joyce studied the way medical experts spoke about MRI technology and found that even though medical experts, through their training, daily operation and exposure to the technologies understood that the images produced do not render the body transparent, "they often used popular rhetorical practices to articulate observations about MRI examinations in everyday conversations with each other and patients" (44). One physician is quoted stating, "now with the MRI you are going to be seeing the heart in real time. You are going to be seeing the lungs in real time. You are going to be marching through the body with MRI" (Joyce 57). As is the case in public discourse, this physician discusses the images as if they can stand in for the heart and lungs and that these images are authentic and unmediated. As has been discussed previously, these images are not 'the heart in real time' per say, but instead they are representations of the 'relaxation' of atoms. But that is not expressed within these rhetorical practices, instead what is bolstered is the notion of the body as an entity "outside of human relations and can be known" (Joyce 448) by the 'objective' lens of the MRI - and that the body can be traversed, clicked though or 'marched through'. This assumption not only leads to images standing in for the physical body, but suggests that there is an "a priori body that exists outside of human mediation" (Joyce 440). This further suggests that with the right tools the body is completely knowable and our uncertainties about disease and illness can be overcome provided we can 'see' into the body using 'objective' and unmediated tools.

"In my research, technologists – in response to questions about their actions at the

> computer keyboard and screen – explained how their decisions about parameter values shaped the content of an image....The body is already in a process of translation and interpretation. Decisions made by technologists constitute via productions and erasures, pathology and its absence in each given image. These visible symbols of 'disease' or 'health' may have no physical referent in the body being scanned. Discussion of the technologists' tacit knowledge demonstrates how the anatomical image does not provide a transparent 'window' into the inner body, but instead produces the body." (447)

Of course, through their knowledge and professional training, physicians know that an MRI device does not serve as an objective, unmediated transparent window but they often deploy rhetoric to discuss the process of imaging examinations that suggests otherwise, perhaps in hopes of appealing to patients who are already exposed to public discourses that repeatedly reproduce such claims. The use of these narratives by professionals indicates how medicine is a social practice, and how ideologies and cultural narratives are closely interlaced in medical practice. Through these rhetorical practices, the MRI becomes a non-human actor (Latour) ascribed with agency that advances the conception of the MRI as transparent and the images it produces as interchangeable with the lived body. This further reinforces the notion that the products of medical imaging devices are objective knowledge, free from human interaction, values or constructs and they offer an unmediated truth.

Any diagnostic process incorporates a number of actors and resources, from technicians to machines, physical exams, atlases and trained knowledge before a diagnosis is made (or not). MRI or any sort of imaging apparatus then does not independently 'speak' for a patient as rhetoric suggests. Further, these images are not exact surrogates for the body under inspection, they are implicated in a complex network of actors and work practices. The rhetoric that suggests transparency or that these images "exist outside the realm of human action" simplify and hide the "relationships that exist between bodies, technology, decisions and actions in imaging units, and anatomical pictures" (Joyce 457).

In addition, what is overlooked in the assumption that these images are equivalent to the body is that the technology is not completely unmediated and has the potential to 'act' on the images in a sense. 'Artifacts' on an MRI scan are forms that appear in the image, usually in the shape of wavy lines, double images or black or white spots (448). These 'artifacts' can be created by a number of sources such as pulse or blood flow or administered supplemental oxygen (Krupa and Bekiesińska-Figatowska 1). These artifacts are easily misidentified as anatomy and are considered "effects of the technology" by radiologists and technologists (Joyce 448). In this instance, the technology in a sense 'added' something that is not indicative of a patient's actual physical anatomy. When the MRI scans are presented as 'windows' into the body or as if they were realistic photographs, the fact that they are images derived from a complex process of magnetic fields and radio waves that can be disrupted in a number of different ways gets lost.

While the imaging aspect is the most prominent in popular discourse, as well as in a clinical setting, some users of the technology refer to the numerical components of the scan as the primary source of information (Beaulieu 663) a position that can protect against these sorts of misinterpretations and further, one that indicates that images are simply one aspect and one way to read the information gathered by the use of an MRI machine.

Moreover, while the majority of patients will present very similar anatomical markings or details, there are those that will fall outside of the norm. In these individuals, the scans present 'abnormal' findings in comparison to atlases or other bodies but are 'normal' i.e. healthy for these individuals. These anomalies present as 'unidentified bright objects' (UBO) or as one physician refers to them ‘old friends’,

> “Some of these old friends are simply anatomical variations from person to person. We all have different noses, different eye color and different looking hair. You know that all those hairs and noses are normal but they all look different. There are variations in the brain as well” (Joyce 450).

When these images come to stand in for the physical body, or the rhetoric suggests that they can be interchangeable, this advances a notion of universality that belies the diversity and idiosyncrasy of actually existing human patients and their bodies. Much like every image of an individual’s outer features would present similarities and differences, scans of the internal body show anomalies or UBOs. Here again, what is determinative is not necessarily the technology itself and the images produced but a radiologist’s skill in interpreting the image. As one physician noted, “if I were to take 100 outwardly normal people and take MRIs of their brains, maybe 20 people are going to have something that is going to be read out by a very good radiologist as not quite normal” while a subsequent physician emphasized “you have got to pick places where the radiologists are going to be good. People don't understand it’s not just about the technology. You can get pictures but it’s the interpretation of those pictures that’s key” (Joyce 452).

It is once the image is produced that the physician or radiologist must interpret the image and make decisions about what is an artifact or UBO and what is disease. These decisions lead to further examinations or potentially treatment, which becomes problematic and dangerous if the scan is misinterpreted. This complicates the notion of MRI technologies and other imaging apparatuses as offering a transparent ‘window’ into the human body. It further debunks the notions of imaging technologies as free from human mediation, for human interpretation is crucial in the effective use of the MRI as a diagnostic tool and in the larger assemblage of an examination. Further, MRI cannot, in many cases, offer complete diagnostic closure for "complete diagnostic certainty does not exist" (Reed et al 20).

VI. Bodies Act on Machines

The use of imaging technologies such as MRI has implications for how we perceive our own bodies and how we understand the functionality of medicine and healing. However, the body under examination in these instances is not passive. While an MRI acts on the body and on our conceptions of our bodies, the physical body acts on the MRI as well. Lisa Wood, in her exploration of the work practices involving the Cone Beam Computed Tomography system (CBCT) found that the images produced during this procedure are not depictions of a passive body, rather they are "co produced by the work of practitioners and patients who actively control (and contort) and discipline their body according to protocols, instructions and the CBCT system" (768). The patients' bodies are not simply the subject of the image but active in its production. In producing an adequate image, patients are responsible for disciplining their bodies in a number of ways; their participation in these activities (both voluntary and involuntary) is crucial in shaping the image. Goodwin, for instance, suggests that patients under anesthesia enact "agency without intentionality". These patients, Goodwin argues, are cyborgs in that they are hooked up to, and therefore part of, machines. These machines give patients opportunities to communicate,

> "In rendering the patient unconscious, the use of language and gestures is disabled. But a silent body is not necessarily a passive, uncommunicative body; indeed, the patient must still communicate to indicate his status to the anesthetist...being technologically

augmented, the cyborg's expressions are amplified" (Goodwin 356).

He cites instances where a patient's pulse drops dangerously low, or 'beeps' coming from the anesthesia machine suggest that their 'block' has worn off and the patient is in pain. The patient's body is able to communicate its internal function in an amplified way with the use of the machine it is connected to. For Goodwin, this is an act of agency on the part of the patient that suggests humans act *on* medical equipment and are not simply passive subjects of examination.

Similar notions can be applied to the patient's role in creating diagnostic images. Prior to an examination a patient may be requested to fast, drink a certain quantity of liquid, or to remain immobile during the procedure. In an MRI examination, metallic and other foreign properties in a body such as makeup, jewelry or hair bands, can influence the results of the scan (Krupa and Bekiesińska-Figatowska 1). Often, patients are requested to remove these objects and in conforming to these requests are enacting agency on the resulting images. There are also ways in which the body acts on the images that cannot be disciplined, such as breathing, heartbeats, implants or tattoos that can all influence the scans enacting 'agency without intentionality'.

When the role of the patient in creating a valuable image is overlooked, human participation in an examination seems passive. Such an account of the relationship between human and non human actors bolsters the standpoint that medical imaging technologies are objective and transparent forms of knowledge and thus "smooths the path for incorporating imaging technologies into practices with unquestioned acceptance in the eyes of the public" (Wood 769). The images that result from the process of an MRI examination are not, as is often thought, objective depictions of reality, unmediated by human subjectivity. Instead, they are the resulting reproductions of a very real actively participating body created through the complex conditions of its production.

Finally, there is again, a notion of morality closely tied to the agency enacted by these patients. In neoliberal, technology-centered healthcare, conforming to these expectations that in turn produce an image of 'value' is expected as part of an individual's duty to self monitor and ensure their personal health. In disciplining their bodies in prescribed ways as to produce effective results from the medical imaging equipment, the patients are acting as 'good' or 'responsible' patients, thus moralizing their agency.

VII. Body Images and the Lifeworld

The medical context and discursive practices in which medical images are produced act on the meanings inferred from the scans. That being said, MRI and other medical imaging scans are not only present within a clinical setting. The Visible Human Project (VHP) is an example of medical imaging of the body offered up in the public arena. The intention of this digital database was still to be used as an educational tool within science and medicine faculties. However, images produced by medical imaging devices have become prolific outside medical contexts, particularly in popular culture and art. These images hold great fascination for the layperson, which is particularly interesting when we take into account how little an MRI scan resembles any sort of body part or image that we may recognize. Some scholars however have argued that here is in fact something that draws us to these images and a level of recognition, albeit not in the traditional sense. Jenny Slatman analyses the late twentieth century rise of 'body art' - artistic works that focus on representing the body, often by utilizing imaging techniques developed for medical purposes. In her analysis she suggests that these images are interesting because they speak to us at either a narcissistic or affective level. The narcissistic image refers to the image of one's body as a subjective identity opposed to a body as object or organism. This image, while always in flux, represents one's identity or the way that a person recognizes themselves at the most fundamental level. It is closely linked with the notion of 'body schema,' developed in the 1930s as a term to refer to the unity of the body both 'real' and subjectively experienced, as it is in instances of phantom limbs. In 1935, Paul Schilder suggested that the term 'body image' be used instead to describe all aspects and ways one identifies and experiences one's body. For Schilder the term "image" is crucial because he argues that the body image is in fact the image that one forms in their mind of themselves. What the body looks like, how it is experienced and the recognition and awareness of its position in space is the "tri-dimensional image everybody has about himself"(Schilder 11). As, Slatman points out, this dependency on 'image' in the creation of one's identity is reminiscent of psychoanalytic theory which suggests that the identity of an individual is not innate but formed though developmental stages. Freud suggests that the initial formation of one's identity, or more specifically the process in which one realizes their 'oneness' occurs when one experiences the body beyond self-preservation or survival needs (Freud 70). This stage of 'narcissism' represents the shift of understanding one's body as organism and in the realization of the subjective body and in this shift an 'image' of the body begins to form.

The importance of images in the formation of identity is echoed in Lacan's conception of the "mirror stage" of development. Early in development, prior to the mirror stage, an infant experiences the body as fragmented, for instance the experience of the mouth while feeding as being disjointed from the rest of the body. During the next developmental stage, the mirror stage, the infant finds bodily unity in its ability to recognize itself in a mirror. This stage is dependent on body image and while it is only later on in development that the infant can distinguish its own refection from another's, it is the image of the body that initially begins the path of identity formation. As a person develops, images remain important to the negotiation of one's identity. Gail Weiss in her book *Body Image*, argues that throughout our lifetime we use images to create our identities. The way we perceive our bodies often is in relation to other bodies, or other body images we encounter or images given to us through society (i.e., thin bodies, tanned bodies, etc). Weiss calls these 'ideal body images' and while it is not to say we internalize every ideal body image we encounter, but we do use them as reference points for how we embody and imagine who we are or who we are not. These images arguably become part of our 'life world', which refers to Husserl's notion that "all our human knowledge is built on the everyday lived experience of the world" (Lauritzen and Hydén 5). Medical imaging scans, particularly through their uptake in popular culture and art offer an interesting point of examination. These images are not recognizable in the traditional sense; in the same way photographs for instance are, yet there is a distinct interest in them as they become part of our life world and recognition of our bodies.

In the case of art that depicts the interior of the body, although it represents body parts, it represents parts that we have never been able to see in ourselves. Likewise, this would seem to suggest that images such as scans produced by MRI cannot be integrated into our body images and could not represent ideal body images. But there is in fact some recognition in these images. Through her analysis of *Corps Étranger,* an art installation by Mona Hatoum that displayed and projected the interior body by the use of medical imaging technologies such as an endoscope, Slatman coins the term "affective image" to account for the recognition of these images that cannot be explained by the narcissistic body image. She states,

> "Aesthetic pictures of the interior body might encourage us to integrate the disjointed inside in the body image. While penetrating the skin, the invasive gaze of the endoscopic

> camera turns the interior into a surface. Both the body's skin and its physical outline seem to have lost their privileged status with respect to the ego as a projection of the body. The projection screen of the ego now includes newly visible body parts. My hypothesis is that although they are hardly recognizable, we do recognize something in these images. Beyond the narcissistic image we may encounter our own strangeness" (196-197).

Interest in images such as MRI scans is affective and by being introduced to these new ways of 'seeing' parts of our bodies, these images become part of our body images and bodily conception.

Silvia Casini argues that MRI images, particularly those found in the context of art installations or in popular culture are in fact *performative* images akin to self-portraiture. They are recognizable, yet she resists the notion that they are transparent windows into the self (73). Casini argues that in contemporary portraiture, "the main feature of the portrait is not necessarily that of representing in the sense of resembling" (91) yet they always do implicate notions of likeness and identity. MRI images are unlike previous media used in self portraiture much as cameras, videos or painting in that they do not represent "structures and functions of certain organs" but rather they are 'image data' that is computer generated visual reconfiguration of physical data. This does not quell interest in the images outside of medical contexts. There is often, a 'shock of recognition' when confronted with these images. In the instance of MRI scans the images "enact the body, rather than represent it" (Casini 92) and certainly do not offer transparency in the traditional sense. Imaging technologies no doubt have played a role in re-conceptualizing the body and boundaries between the physical and the social body become less clear. When images such as MRI scans cross from medical contexts and enter the realm of art, popular culture and daily life the become a part of our ‘life worlds’. These images become recognizable and influence how we view, understand and think about our bodies and identities.

In contemporary culture, medical imaging technologies such as the MRI device occupy a privileged status as authoritative and objective sources of information. It is commonly assumed that the MRI offers visuals akin to photography and therefore render the body transparent and knowable. Further, because of their privileged position it is assumed these machines offer impartiality and truth free from human mediation. These discourses erase the multitude of complex networks, produces, work practices, decisions and contexts that make up an MRI examination. This ‘black boxing’ or erasure of these forces serves to bolster the common discourses, even among medical professionals. Through the course of this chapter these notions have been complicated and demystified. In addition, this chapter has looked at the ways that technologies such as MRIs not only impact the way in which pathology is diagnosed but how patients and the population more broadly understands and thinks about their lived bodies. Images produced through MRI often come to stand in for the physical body in examinations of illness. In this way the body seemingly becomes a fragmented knowable entity instead of a unified complex system. MRI images are often understood in much the same way as photography and therefore is caught up in discourses of objectivity that often follow mechanical reproduction. This chapter has looked at the ways in which human agency, interpretation and decisions are crucial in the creation of MRI scans as well as in the process of diagnosis. Human agency is also present from the position of the patient and the potential for patients to act on the machines was discussed. While the majority of this work has focused on the use of MRI and other imaging scans in clinical contexts, this chapter briefly considers the dissemination and use of medical images in popular culture and art installations. When these images are embedded in a new context they also take on new meaning and implications. This chapter looks at how when these images cross over into culture they become a part of our life worlds and become a part of our self-identities and a part of our mental construction of our bodies. The intention of this chapter was to create a cultural analysis of the MRI and to identify, complicate and demystify cultural ideologies and discourses pertaining to the use of MR imaging in medical contexts and beyond and the process of diagnostic examinations as a whole.

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Conclusion

Medical imaging technologies such as the Magnetic Resonance Imaging device occupy a privileged and authoritative position in clinical medical practice. Their status extends into popular culture and the discourses they are implicated in revere these technologies as objective, unmediated methods of peering into the body so that the body is rendered transparent.
By closely examining these discursive themes and contextualizing them through the development and use of MRI technology both within clinical capacities and beyond, this work challenges common assumptions. Discourses that describe MRI devices as omnipotent are generally founded in ideologies that conflate visual representation with the 'real' and mechanically or automatically produced images with the objectivity ascribed to machines. These discourses are generally established without knowledge pertaining to MRI technology specifically or the work practices involved in operating the machinery.

When the MRI is taken up into discourses that position the scans produced by this technology as images akin to photographs, assumptions that the images are the same as, or can be interchanged with the body follow suit. These beliefs in turn allow for assumptions that these scans extend the limitation of the human senses and offer up a photographic like image of the previously mysterious interior body. These tropes marginalize human agency in the production of an MRI scan as well as presenting the MRI as an infallible device.

These discursive practices also influence the way we conceive of our bodies and our power over the pathologies living under the skin. In contemporary culture 'seeing is believing' and so easily this turns into an assumption that if we can 'see' something we can enact our will upon it. What this rhetoric leaves out however is that there are many pathologies that are not visualisable, yet this does not mean that they do not exist. There are many pathologies that we can visualize but cannot treat. Further, the technologies that are used the most become the foundation of our knowledge. Using atlases of MRI scans for instance for research and analysis becomes the narrow scope from which knowledge is derived and shapes further knowledge. There is a moral undertone to many of these discourses. The newest most advanced technologies become an indicator of the best available healthcare, and the further removed human mediation seems the more authority is attributed to the information. Medical imaging technologies such as the MRI do not render the body transparent, seeing does not equate with truth and the ability to visualize does not mean that we have power over what we see.

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