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Title: Self-Portrait of the Artist Meditating on Death: A Feminist Technoscience Reading of the Apparatus of Contemporary Neuroscience Experiments

<A>Introduction<A>

The idea for the Neuro Memento Mori project discussed here began when I saw a wax vanitas object on loan to the Wellcome Trust Permanent Collection from the Science Museum, London. This life-sized wax head of a woman, entitled “Wax model of a Female head depicting life and death,” was produced by an unknown artist between 1700 and 1800. It shows a woman’s head, bisected, the left half apparently a detailed portrait of a living woman. She is open-eyed, with painted lips and eyebrows made with real, carefully embedded hairs. Her blond hair is arranged in ringlets and held back from her forehead with hair combs. Her left hand frames her face and in some photographs holds a small posy of flowers. The right half of her head is shown in a state of post mortem decay. Resting on her skeletonised hand, her skull crawls with insects, maggots and worms. A spider and a snake emerge from her empty eye socket. A wax snail apparently slithers along the wooden base that the head is fixed to, making the base an intrinsic part of the overall work. Attached to the base, next to the snail, is a handwritten label, again rendered in wax. The label bears a Latin phrase from the biblical book of Ecclesiastes, that reads, “vanity of vanities, all is vanity.”

[Vanitas](http://www.tate.org.uk/node/296581) are usually [still life](http://www.tate.org.uk/learn/online-resources/glossary/s/still-life) works, not portraits, though they are closely related to memento mori and the two terms are often conflated. While symbols of mortality dominate memento mori paintings, vanitas usually allude to worldly pleasures by including images of goods such as musical instruments, wine and books. Memento mori are usually portraits, rather than still lives, often with a skull included and symbols of the inevitability of time passing, of death and of decay such as hour glasses or clocks, burnt out or guttering candles, rotting fruit, and flowers with their petals falling. The compelling wax vanitas object described above prompted me to look more closely at the memento mori and vanitas genres which were especially popular in the seventeenth century, but remain alluring to contemporary artists and art audiences. I began by questioning if, as we look at memento mori artworks, we are, as intended, prompted to contemplate our own mortality. I wondered what parts of the brain are active when we look at these artworks and what parts are active when we contemplate death directly, without looking at memento mori art. This lead to my wish to make contemporary memento mori through an entanglement with neuroscience. The series of artworks and papers discussed here have emerged through a collaboration with neuroscientist, Zoran Josipovic, anthropologist turned neuroscientist, Andreas Roepstorff and psychologist turned neuroscientist, Joshua Skewes. Conversations with anthropologist and ethnographer Ton Otto have been an essential part of the project development and he gave us the opportunity to show the first artworks in the large ethnographical exhibition “The lives of the dead” at Moesgaard Museum, Aarhus, Denmark.

<Insert figure 1>

During the years it took to gather a team of collaborators and find funding for the project there were several breakthroughs in neuroscience research and neuroimages proliferated in the popular press which made me want to better understand the history of neuroscientific research and imaging. As I read more I was especially struck by the use and effect of metaphors of “the pioneer,” and frontier rhetoric which was also apparent in governments’ arguments for allocating significant funding to neuroscientific research. One such example was the US BRAIN Initiative, launched in 2013. Barack Obama Tweeted, “If we keep taking bold steps ... I’m confident America will continue to lead the world into that next frontier of human understanding.” Scholars of rhetoric have argued that the use of pioneer metaphors is key to the funding of scientific research (Ceccarelli, 2013) and proposed that competition, patriotism, bravery and return on investment comprise four key tenets of frontier of science rhetoric (Rainko, 2015). Obama’s April 2013 speech (Obama, 2013) about the then new BRAIN Initiative had each of these tenets. Early on he addressed return on investment, saying, “Ideas are what power our economy (…) every dollar we spent to map the human genome has returned $140 to our economy -- $1 of investment, $140 in return”. He moved on to address competition, “I don’t want the next job-creating discoveries to happen in China or India or Germany.” Towards the end of his fourteen-minute speech he brought in bravery and patriotism “it’s going to require a serious effort, a sustained effort.  And it’s going to require us as a country to embody and embrace that spirit of discovery that is what made America, America.” While metaphors of the frontier and pioneer are commonly associated with America, their use in science rhetoric is global. The EU funded, Human Brain Project, also initiated in 2013 with a US$1.3billion grant, claimed understanding the brain to be “one of the greatest challenges facing 21st century science” and their mission includes, “Advancing the frontiers of brain-inspired technology” (Human Brain Project, 2013).

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The US-Russian space-race was also described using the metaphor of the frontier “a characterization of space as a beckoning frontier; an articulation of time that locates the endeavor within a historical moment of urgency and plausibility; and a final, cumulative strategy that invites audience members to live up to their pioneering heritage by going to the moon.” (Jordan, 2003). Like the space-race, the global funding of the so-called “brain race”, this time between the EU and the US, has contributed to the development of new scientific instruments, in this case capable of safely imaging living human brains, and led to a rapid and significant increase in neuroscientific research data. However, controversy surrounds much of this neuroscientific data. There are debates over methodology that suggest flaws in experiment designs; challenges to interpretations of the data; concerns about the ‘seductive allure’ of neuroscientific explanations and of neuroscientific images; ethical concerns and anxieties about how discoveries might be used. Against this background, a better understanding of neuroimages became an essential part of the realisation of my artwork.

My relationship with neuroimages is as a visual artist working from a new materialist perspective. The term “new materialism” was coined by Rosi Braidotti and Manuel DeLanda, independently of one another, in the second half of the 1990s and was defined by Jussi Parrika as concerning “a series of questions and potentialities that revolve round the idea of active, agential and morphogenetic; self-differing and affective-affected matter” (Parrika 2010). I consider neuroscientific images to be “vital” matter, having many potentialities and with particular meanings emerging through intra-actions. The meaning of images morph, emerge differently, depending on these intra-actions: the specific time, place and bodies involved. When I looked at a neuroimage that illustrated a newspaper article before working on this project, I remember being struck by the composition, the bright colours that ‘lit up’ the black and white MRI of a human brain. Then, I assumed the meaning ascribed to those colourful areas was whatever the caption or article told me. Now, when I look at similar images I wonder what prompts or cues the human subject had been given just before the image was made, what other areas of the brain were active at the same time that we are not being shown. I knew that each two-dimensional MRI slices co-exists with hundreds of others from the same scan, but I had not thought through the implications of which images were selected and which discarded when scientists and journalists prepared articles. Now I am aware that colorful MRI and EEG images do not reveal the brain activity in 3D in the way that simpler, more diagrammatic “glass brain” images show. While not so compelling the “glass brain” images are important to the meanings we make of neuroimages as they show whether multiple areas of the brain are active during a given task. Presenting only one or two of the more seductive MRI images might be telling only a fraction of the story. While the use of MRI versus glass brain images may later the meanings that a trained neuroscientist makes of research, the non-expert might be influenced just by the presence of a neuroimage accompanying a newspaper report. The so-called “allure” of the neuroimage can impact how believable the claims in the accompanying article are. It has been shown that for the expert neuroscientist, the image does not sway the written argument that accompanies it, but that for the non-expert the neuroimage may make any explanation seem more likely (Weisberg, et al. 2008). The multiple meaning of an image, its “self-differing”, is such that it is useful to think of images and other materialities as “not a thing but a doing” (Barad, 2007). The scholar of rhetoric, Laurie E. Gries suggests, “images conceived as events can be studied as a dynamic network of distributed, unfolding, and unforeseeable becomings” (Gries, 2013). These “active” images are constantly being affected by other things in the network, and at the same time affecting the network. This is markedly different from viewing neuroscientific images as fixed and truthful, as objective.

My thinking about, and practice involving, the observation and imaging of the human brain also uses Karen Barad’s theory of ‘agential realism’ to understand the technoscientific production of knowledge and reality. According to Barad, “[Agential realism] is an epistemological and ontological framework that (…) takes as its central concerns the nature of materiality, the relationship between the material and the discursive, the nature of “nature” and of “culture” and the relationship between them, the nature of agency, and the effects of boundary, including the nature of exclusions that accompany boundary projects. Agential realism entails a reformulation of both of its terms — “agency” and “realism” — and provides an understanding of the role of human and nonhuman factors in the production of knowledge, thereby moving considerations of epistemic practices beyond the traditional realism versus social constructivism debates.” (Barad, Meeting the Universe Halfway 2007, 89)

Agential realism is a way of understanding the politics, ethics, and agencies of different kinds of observational acts. Barad uses the term ‘apparatus’ to elaborate on the way that representations of an experiment emerge. For Barad, “apparatus includes both processes that get labelled as “scientific” and processes that get labelled as “social”. Apparatus are not just the set of instruments or mediating devices needed to perform an experiment, instead apparatus is the arrangement of nonhuman and human material-discursive forces” (Prophet and Pritchard, 2015). The so-called “material-discursive forces” at play in the collaboration discussed here include experiment design, MRI and 3D print technologies, curating practices from fine art and anthropology. These forces are entangled with the particular human biographies of artist and neuroscientist, such as the meditative practices of two of the neuroscientists which has influenced some of their research topics. This is only a fraction of the apparatus we are part of, “through which particular concepts are given definition and through which particular physical properties are produced” (Prophet and Pritchard, 2015). Barad’s apparatuses produce phenomena relationally, depending on the particular materiality of intra-actions between humans and nonhumans. Such apparatuses are ‘material-discursive’ producing certain determinate meanings and material beings, while simultaneously excluding the production of others. For example, the academic psychologist, Cordelia Fine has analysed numerous neuroscientific studies documented in peer-reviewed science publications in order to challenge claims of biologically-determined sex differences in the brain. Some scientists have presented data to suggest that the women’s brains are ‘naturally’ different from men’s brains, excluding other reasons for such differences. Fine does not dispute that there are differences between the men’s and women’s brains used in the studies, rather she suggests that the meanings made from the data gathered, which includes and is embedded in neuroimages, differs depending on the discursive environment in which the data is situated. The scientists she calls to account interpret the data as ‘proving’ that women’s brains are intrinsically different from men’s brains. By contrast Fine suggests that when viewed as part of a feminist discourse the same data may simply show that life experience has produced the differences seen between the images of these particular men’s and women’s brains. Fine is questioning the neuroscientific apparatus used by the scientists (the way they design experiments, collect data and interpret it). “A third important issue when it comes to interpreting sex differences in the brain is the potential plasticity of sex differences in both brain and mind. Neural circuitry develops through, and is altered by, experience […]. As a number of feminist scientists have pointed out, gendered life experiences and social constructions of gender (such as leisure activities, educational interests, poverty and status) have material effects on the body, including the brain.” (Fine, 2013). In this argument, Fine draws attention to the materiality of particular intra-actions between the humans and nonhumans involved in the studies that she is challenging and at the same time she is showing how indeterminate those meanings are. As part of my art practice I endeavor to view neuroimaging apparatuses as part of the practice of producing neuroscientific phenomena. ‘How’ neuroimages are materially-discursive, how they are part of the thinking and the conceptual models of neuroscience, matters. Barad’s idea of an ‘observational cut’ is important here, that any act of observation ‘cuts’ that which is included from that which is excluded in the observation. In the example above, the scientists cut out any consideration of either gendered life experiences or social constructions of gender when they argued for purely biological differences between men’s and women’s brains. Agential realism shows us that neuroimages are not separate from the human brain, they supposedly represent, even though they might momentarily appear so when we make an observational cut to create them. Rather the images themselves are part of our emerging understandings, knowledge and models of the brain. Furthermore, neuroimages only emerge when humans intra-act with nonhumans as part of neuroscientific apparatuses.

Accounting for my agency, for the impact of my role as simultaneously experimental subject and observer, entangled and intra-acting with the apparatus of neuroimaging, caused me to shift from describing our enquiry as a Baradian diffractive reading to ‘diffractive art practice’. Like many art students in the 1980s, I become familiar with the optical metaphor of reflection. I deepened my awareness of my art and teaching practice during my PhD in the early 1990s by reading more about Reflective Practice. When I first came across references to new materialism and the optical metaphor of diffraction it was therefore especially intriguing to me. One example of diffraction is “the [visible] diffraction or interference pattern that water waves make when they rush through an opening in a breakwater or when stones are dropped in a pond and the ripples overlap” (Barad, 2007). While the metaphor of reflection in both art and technoscience practice “place[s] the same elsewhere” (Gibbs, 1998), diffraction looks for difference. “If we take the example of ripples that appear when stones are dropped into a pond, where dynamic and overlapping ripples change one another’s form, we can see that diffractive patterns are always in movement, a movement we are also situated within. We only see the differences of the water and the stones when they are in relation to one another, when the stone is thrown into the water and the ripple appears. […] Diffraction reveals the ways materialities emerge as differentiated events, as they come together, in relation to one another, and this includes the materiality of stone, water and the thrower. Whereas the common metaphor of reflection […] might be to ‘look back onto’ arts practice, diffractive patterns manifest through reading practices through each other. In the metaphor of diffraction, diffractive patterns describe intra-actions. […]” (Pritchard and Prophet, Diffractive Art Practices, 2015). I was drawn to this metaphor of diffraction because when applied to practice they remind us of the active role of the artist and the nonhuman factors in the production of knowledge. The way that diffraction accounts for difference, for paying attention to ripples and disturbances, resonated with my experiences over the years of working with scientists, where our differences (and disagreements) and the disturbances our intra-actions made seemed to be as important (if not more important) as our shared goals and “successful” research outcomes. “‘Diffractive practice’ reminds us that we are not simply observers or readers but artist practitioners, it prompts us to make close ‘readings’ of our practices as artists, as well as the practices of the biological and computer scientists that we work alongside.” (Prophet and Pritchard, Performative Apparatus and Diffractive Practices, 2015)

The perspectives, experiences, contacts and discourses that form my art apparatus are different from those that form the apparatus of a particular neuroscientist, psychologist or anthropologist. With that in mind, I appreciate how generous my collaborators have been, especially for the way they have engaged with the idea that each of us becomes so acclimatized to the norms of our own material-discursive practices and processes (our apparatuses) that we become blind to them. We believe it is possible (but not automatic) that the diffractive practices of collaborative teams comprised of members from different disciplines can expose blindspots. By this I mean that we can see things previously obfuscated by paying attention to the interferences we sense when our practices ripple out and overlap with those of another’s, and via the subsequent questioning of one another’s necessarily unfamiliar processes and discourses. We hypothesize that close readings of diffractive practice-as-it-happens will further highlight the interferences between our patterns of practice.

<A>The problem of ‘inter’ disciplinary collaboration<A>

Over the last twenty years I have made artworks in collaboration with a number of different scientists, including a biologist, a cardiothoracic surgeon and a stem cell researcher. In addition to producing art, some of these collaborations generated papers published in journals relevant to our respective disciplines, addressing not only our shared and individual research foci but also the experience of working together (Prophet and d'Inverno, Transdisciplinary Collaboration in CELL 2008). Repeatedly, in different collaborative projects, my experience has been that interdisciplinary collaboration challenges each collaborator’s preconceptions. In 2004, I wrote of one such experience, “We each asked many questions about why certain paradigms were in place and what it would ‘cost’ someone to contradict them. Through such discussions we each developed deeper understandings of the discourses and context that the others worked within. This caused us to question our individual assumptions about other disciplines, and indeed of our own, and in most instances to revise our worldview in some significant way”. (Prophet and d'Inverno, Creative conflict in interdisciplinary collaboration 2004, 255) In retrospect it seems to me that we were describing a diffractive practice and articulating some of the interference patterns that emerged as part of that.

In the late 1990s and early 2000s, we realized the value of this often uncomfortable questioning of our paradigms retrospectively, after considerable discussion and thought. In subsequent interdisciplinary collaborations, and in my solo explorations of novel materials, discourses and protocols, such questioning has become an acknowledged and deliberate part of my material-discursive art-making. It is as though, having experienced and acknowledged the revelatory process of diffractively reading one set of practices against another, I cannot forget the differences revealed by such diffractions. What is known cannot be unknown.

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For me ‘what is known’ now includes an unease about terming such collaborations ‘interdisciplinary’. This unease is an interference pattern that forms at the overlay of our different disciplines, sensed when the ripples from our different practices collide. I have learned to ponder over unease, difficulties, mess and discomfort in collaborative working and in data, to interrupt my first response to ‘tidy up’, solve the problem, or smooth the difficulty because messy interference is often revealing. The unease around ideas of interdisciplinary practices first emerged from my awareness that many scientists I work with are skilled in other disciplines, for example, the British biologist Julian Vincent led the Department of Mechanical Engineering at the University of Bath; the neuroscientist Andreas Roepstorff began as an anthropologist. Over the last decade I have wondered how useful or possible (beyond the important grant-winning and publishing imperatives) it is to draw a line between one discipline and another. Interdisciplinarity seems to me now, as Des Fitzgerald and Felicity Callard have described, a “regime of the -inter, an ethic of interdisciplinarity that guides interaction between disciplines on the understanding of their pre-existing separateness.” (Fitzgerald and Callard 2014, 3) Even if a discipline could be defined, by making an observational cut, I wonder how such a cut might account for the way lived experience, culture, and politics inflect the way each person practices within their discipline. The mathematician Mark d’Inverno is also a jazz pianist, the cardio-thoracic surgeon Francis Wells is a Leonardo scholar who uses drawing in his everyday surgical practice. Another collaborator, Neil Theise, states on his homepage “[e]verything in this website –– derives from observing liver biopsy specimens with what in Zen practice is often referred to as beginner’s mind and from sharing these and subsequent observations with creative individuals from diverse disciplines.” (N. Theise 2015) As Fitzgerald and Callard argue, the term ‘interdisciplinary’ is not helpful, it “is no longer practicable to maintain a hygienic separation between sociocultural webs and neurobiological architecture [and] that the cognitive neuroscientific experiment, as a space of epistemological and ontological excess, offers an opportunity to researchers, from all disciplines, to explore and register this realization.” (Fitzgerald and Callard 2014, 3)

<A>Looking at memento mori with a ‘period eye’<A>

At the heart of memento mori artworks, and the vanitas still life works closely-associated closely with them, is the belief that by looking at them, viewers are prompted to consider their own mortality. Typically, as illustrated by the description of “Female head depicting life and death”, living and dead are brought together. A living person is shown holding, or near to, a skull; a still life combines skulls, wilting flowers and decaying fruit. Supposedly, these works make viewers consider the transience of their own lives, the futility of pleasure, and the certainty of death. However, while similar-looking images and objects can be found in numerous cultures, we cannot assume that they have the same function or meaning. As neuroscientist Edward Vessel and his co-investigators note, “aesthetic judgments are not only subjective but also highly susceptible to cultural norms, education, and exposure.” (Vessel, Starr and Rubin 2012, 1) Art historians have made similar arguments; Ernst Gombrich claimed that the meaning a viewer makes of a work of art is influenced by factors such as the larger cultural and political contexts of the artwork (Gombrich 1960).We can apply this thinking to the argument that Christian viewers of memento mori would consider their afterlife and a concurrent moral imperative to live without sin.

The selection of images viewed in our experiment was influenced specifically by art historian Michael Baxandall’s argument that a viewer looks at artworks with a unique ‘period eye’ (Baxandall 1988). Emphasizing the situatedness of the viewer, Baxandall’s theory of the “period eye” holds that specific combinations of innate skills (some of which presumably relate to the processes of eye-brain function) and socially developed skills influence the meaning each viewer makes of an art work at a particular time. The “period eye” describes the sensitivities we develop through particular experiences, the way we become attuned to recognizing or ‘reading’ particular patterns, for example, when Renaissance painters used ultramarine blue to define the robes of the Virgin Mary they did so knowing that their contemporaneous audience had a shared “period eye”, that they knew that the pigment was expensive to produce using ground [lapis lazuli](https://en.wikipedia.org/wiki/Lapis_lazuli). Those contemporaneous viewers had learned to recognise the “pattern” of ultramarine and assign it a high value, that high value was then afforded to whatever was depicted using that colour. We were aware that the various memento mori and control images we selected were likely to trigger a variety of sensitivities and we therefore selected images of similar forms and styles for each set (memento mori and control). This approach that we adopted has been used by other scientists who study how the brain functions when looking at art. For example, Vessel et al wrote that “an important guiding principle in the choice of our stimulus set was that it should span a variety of styles and periods.” (Vessel, Starr and Rubin 2012, 2)

Vessel et al did this in order to appeal to individual preferences in a multi-subject Magnetic Resonance Imaging (MRI) study of aesthetic responses to visual art where they displayed many different art genres. By contrast, ours was a single-subject case study with a tight focus in terms of art genre, but in order to acknowledge, and potentially test for the impact of the period eye, we selected works from seventeenth century to the present day. In his research into contemporary appreciation of Renaissance art, Pavle Ninkovic suggests that recent neuroscientific developments are akin to a cognitive revolution, and that our new knowledge from neuroscience can influence and enrich our understanding of art, contributing to our period eye and expanding our ‘cognitive style’ (Ninković 2010, 4). These theories surmise that a twenty-first century viewer, looking at memento mori paintings made in the seventeenth century, will not respond to them in the way that seventeenth century viewers did when those paintings were first displayed. However, this is not to suggest that such art works automatically hold radically different meanings for contemporary viewers.

The centuries-old memento mori genre continues in contemporary art, exemplified by Damien Hirst’s 1990 installation *A Thousand Years* where flies feast on a rotting cow’s head and are electrocuted by an Insect-O-Cutor (Hirst 1990). Contemporary curators have noted that considering our mortality is “a topic that has become increasingly relevant as individuals and communities in the developed world seem to value controlling and delaying death, often unrealistically extending the process for the benefit of the living” (Vanderbilt, 2015). This sentiment is echoed in essays and curatorial statements accompanying recent memento mori themed exhibitions (a 2015 online search quickly found sixteen exhibitions over the last decade), most of them mixing contemporary and historical works and featuring works originally made for anatomical science. The quantity of these exhibits suggests that looking at images that combine the living and the dead is still relevant to, and resonate with, contemporary viewers. This may be for more complex reasons than that such images transgress the widespread taboo of discussing death or looking at the dead. As one curator writes, “[Memento Mori] encourage us to reflect on our attitudes to death and […] provide a prompt sheet for contemplation. [… and] have been used as a stimulus to ponder on the brevity of life and use that knowledge as a guide for living. In an age when we try to ignore death, the arts make us aware of what it is to be alive and the responsibility we owe to ourselves, to our families and to our communities as participants in this extraordinary theatre of existence.” (Snell 2014)

<Insert image 3>

<A>Neuro memento mori<A>

If the supposed underlying function of memento mori is to prompt the viewer to consider their own mortality, to contemplate their own death, what parts of the brain are active when someone looks at these works today? Is it possible to calculate brain activity during the contemplation of death? If so, is brain activity when looking at the memento mori similar to brain activity when we contemplate death? In the collaboration discussed here, we attended to these questions by focusing on one specific human subject, the artist. Our MRI scanning began with the gathering of structural MRI data that defines the 3D form of the subject’s brain. Then, in two separate experiments, functional MRI (fMRI) generated data of neuronal activity in the artist’s working brain, over time. In the first of these two experiments the artist lay in the scanner and viewed projected images of memento mori paintings and objects, interspersed randomly with a set of control images, each image preceded by a 7 second linguistic cue, “Live the now” or “You will die,” also randomly displayed. The control images were figurative, but the people in them seemed very much alive. Both sets included paintings and 3D objects in equal quantity, from similar times, ranging from the 1700s to the present day.

Notwithstanding my position against disciplinary boundaries, some might classify this experiment as neuroaesthetics research because we image the brain while the subject looks at art works. However, this is contra-indicated by our fMRI experiment being coupled to a second experiment that concerns contemplation, described below. Furthermore, both our fMRI experiments are inseparable from wider material-discursive practice, therefore the resulting works of art might better be described as ‘neurocultural products’. Giovanni Frazzetto and Suzanne Anker describe such products as “metaphors to describe and interpret neuroscience knowledge embedded in social values and competing cross-cultural norms within divergent societies” and they distinguish such products from neuroscientific projects that seek to understand art neuroscientifically (Frazzetto and Anker 2009, 815). Similarly, our research is less interested in understanding art neuroscientifically than in exploring the phenomena of contemplating and producing memento mori objects using neuroscience as part of a diffractive practice. The neuroimages that emerge from our work together are translated into 3D data that, through further intra-actions, makes 3D printed neurocultural products, specifically contemporary memento mori sculptures, that highlight “individuality and history, which cannot be reduced to a single organ” (Frazzetto and Anker 2009, 816).

Our work depends on the rapid development of the brain imaging technologies over the past twenty years and the concurrent resurgence of interest in the brain basis of both aesthetic and contemplative experiences. However, we do not seek to reduce aesthetic and contemplative experiences to activity in the brain. Brain imaging has been used to explore a number of significant topics related to contemplative experiences, among them: absorption states, non-referential compassion, and the effects of meditation on attention.

In our second experiment, we used neuroimaging to document an artist’s brain as she observed memento mori and contemplated death and love while in meditative state. This second set of fMRI experiments was conducted with the artist, a novice meditator who trained for seven months under Josipovic’s instructions, performing a series of meditations in the scanner. The scanning process began with neuroimaging of a resting state during which the artist was not meditating. This was followed by a seven-minute control meditation on love and compassion. Immediately following the meditation, while still in the scanner, qualitative data was gathered as the artist verbally reported her thoughts during the meditation. This four minute process was documented from the control room using video and audio. The artist then did a seven-minute meditation on death, followed by a four minute verbal report. At the time of writing, the results of these single subject experiments were not yet complete as the data was still being analysed.

The data from both experiments were put to use artistically, to produce objects. The sculptures that emerged from these experiments, the “Homage to ‘Female head depicting life and death’” series, were made by translating fMRI brain images into detailed 3D data of the artist’s brain and combining it with 3D data of her face and neck. The final product was a series of 3D-printed objects that show both the brain and the active areas identified during the meditation exercises. The life-sized sculptures re-combine these data to produce a dissected form reminiscent of both memento mori and anatomical models (see Figure 1).

Whatever findings emerge from the final analysis of the data, they are likely to be of very limited scientific value. For example, because of the very small sample size, they could not be used to extrapolate brain function while looking at memento mori, or while meditating, across a wider population.

However, the experiment designs and collaborative processes might be fruitful for thinking about future studies with more subjects. By working closely with scientists, using diverse materials and processes to create art works that will first be exhibited not in an art gallery but in an exhibition of ethnography within a museum of anthropology, the Neuro Memento Mori art works emerge through a specific material-discursive practice. The coupling of ‘material-discursive’ reminds us of the move away from binary divisions between material analyses of the body and discursive analyses of the body, drawing attention to the ways discourse and materials interrelate and connect, or, as Barad might say, how they intra-act. Undertaking the work as feminist techno-art-science is not a matter of critiquing science but instead “taking responsibility for the social relations of science and technology means refusing an anti-science metaphysics, a demonology of technology” (Weber 2006, 397)

<A>Minding feminist technoscience: embodying new materialism<A>

To be the single ‘subject’ of a neuroscientific experiment that involves neuroimaging my brain, in my body, is to perform my art work more literally than I have done since being an undergraduate art student in the mid-1980s. Then my experiences of making performance art works, were framed by contemporaneous discourses of the so-called feminist sex wars over pornography and sexuality, just prior to third wave feminism. Subsequent feminist debate, my practice-based research in the field of artificial life (J. Prophet, Sublime Ecologies and Artistic Endeavors 1996) and agent-based systems, and my interest in new materialism and feminist technoscience are all part of my material-discursive practice. Sarah Ahmed’s careful analysis of new materialism, where she takes issue with the implication that feminists were not concerned with matter prior to new materialism, is a reminder that bodies mattered to second wave feminists. Ahmed suggests that “given the concern with the social reproduction of hierarchies, much feminist work might point to the complexity of the relationship between materiality and culture, rather than reducing one to the other.” (Ahmed 2008, 33)

It has been important to remember that to image my brain is to image my body, to be mindful of intra-actions between those processes and practices described as cultural and their materiality. To work collaboratively alongside neuroscientists as part of a neuroimaging practice was to engage with their gestures and their human bodies, to intra-act with the nonhuman protocols of MRI. This included a pre-scan discussion ending with a respectful reminder of the need for me to remove any underwired bra, and being touched as my head was foam-wedged into the MRI brain scanner. My (gendered) body became a complication, a disruption in the scientific material-discourse that needed to be maneuvered into place by scientists. One day, as we prepared to scan, the connection from laptop to projector broke down. As it carried memento mori images into the scanner; it was an essential part of the connected bodies that allowed me to view images as part of our experiments. I was a bridge, standing between two neuroscientists, a bra-less feminist in the doorway between the MRI scanner and the cable room, being a relay, a translator. One male Danish neuroscientist, A, lay on the floor wrangling equipment and yelling instructions in English as, remotely, another neuroscientist, B, lined the image up on a screen in a room that was around the corner. The sound of the rack of computers running the equipment drowned out A’s voice. The feminist repeated A’s instructions loudly to B. B was watching a screen display data that A could not see but that A was controlling from the other room with mouse. B shouted back instructions to A, via me. Without me as a relay they could not communicate over the noise of the equipment as we tried to set up image displays. We were in this situation because a central computer somewhere else in the hospital disabled the projector feed automatically. It could only be reactivated by a human technician who did not work at the hospital. We each swore in our own languages. After three hours we gave up. I fished my underwired bra out of my handbag and put it back on. I would not be going in the scanner today. I had a cup of tea and a digestive biscuit and thought about the scenario as a messy entanglement of humans and nonhumans, as the performativity of data that draws attention to the material cables that live data transmission depends upon. As the neuro memento mori work progresses it becomes clear that imaging the brain to better understand the mind depends on concurrent and particular attention to our bodies. Even when the apparatus ran smoothly, learning to meditate, knowing future meditation will take place in a scanner, necessitated a different attention to my body, and the death meditation required me to immobilise my body in a simulation of death. Stillness resulted in clearer brain images.

We began our collaboration from a shared position that one of the features of realised human life is “embodiment,” a sense of being fully situated within one’s bodily experience. This can be contrasted with different degrees of “dis-embodiment”— a psychological dissociation from the body as the site of pain, trauma and suffering, which, in an existential analysis, can be seen as being driven by the fear of death, of the body’s impermanence. Arguably, it is this “situatedness in the body,” or the lack of it, that radically changes in the process of dying and death. The meditations undertaken in the experiment can be seen from the perspective of awareness practices — key to meditation training — and contemplation of death can be understood as awareness of both the impermanence of the body and of the change in the relationship of one’s awareness of one’s body. Our research explores changes in functional connectivity patterns in the areas of the brain known to process body awareness and the sense of oneself as embodied, and considers how these changes affect the dynamics between the two major networks, intrinsic and extrinsic, in the brain. While it is beyond the scope of this essay to go into the various theories of mind in detail, theories of the embodied mind (Rosch, Thompson and Varela 1992) underpin our experiments. Theories of embedded mind (Clark 2008), take this line of thought further, proposing that mental processes and mind extend beyond a ‘closed-system’ body to intra-act with the environment in which that particular body is situated. Theories of situated cognition (Brown, Collins and Duguid 1989) draw attention to not only the embodied mind’s environment but also to the constant actions of each body and mind. A central tenet of situated cognition is that knowing, which cannot be separated from doing, emerges from intra-actions. All knowledge is situated in, and cannot be separated from, activity bound to social, cultural and physical contexts and to language. Our knowledge, our understanding, the meanings we make, are co-determined, or, in new materialist terms, we might say that knowledge is performative, it emerges with, and through, activities. Like theorists of embedded mind, theorists of new materialism propose that “the mind is always already material (the mind is an idea of the body), how matter is necessarily something of the mind (the mind has the body as its object)” (Dolphijn and van der Tuin 2012)

Here, Barad’s idea of “entanglement” is useful for revealing different material-configurations that interweave and entangle in our project in an ongoing process of intra-action. For example, biological matter, specifically the artist’s body, is simultaneously entangled with creative praxis and scientific experiment, lying still in an MRI scanner, or drawing sketches to describe ways to combine datasets, or meditating. The artist co-designs the experiments with neuroscientists through discussions that emerge from previous and with concurrent neuroscientific experiments with other human and nonhuman bodies. Joshua Skewes and I had a long discussion about the font used for the linguistic cues, aware that it would affect the “stance” almost as much as the precise terms we wrote with it. These entanglements resulted in the production of new entities, 3D printed brains, talks at conferences with differently comprised entangled groupings such as anthropologist and neuroscientists that, in turn, entangle with others (Barad, 2007). However, “[e]ntanglement does not mean that what are entangled cannot be differentiated, discussed or remedied, only that the different entangled strands cannot be adequately dealt with in isolation, as if they were unrelated to the others” (Hammarström 2012, 43).

<A>Neuroimaging history and pioneer rhetoric<A>

The now-iconic live video images of American space pioneers stepping onto the moon were key to the pioneer rhetoric associated with space travel and the ‘colonisation’ of the moon and were produced using the cutting edge technology of the time, video. Similarly, “beautiful” neuroimages are used alongside pioneering metaphors in neuroscience. The history of the materiality of neuroimages shows images continually emerging through multiple intra-actions between science, technology, politics and economy. The funding of neuroscience research, which spurred technological developments, has lead to a proliferation of neuroimages and significant quantities of large datasets, typically many gigabytes and terabytes of image data. This is a relatively new scenario. Until recently, the relative lack of knowledge about the way the human brain works was attributed to a paucity of data, the result of historical limitations of technological instruments used to measure living brains. Neuroscientist Fred Mendelsohn notes that in 1960 “there was no way to image the structure of the living brain; the skull represented a virtually impenetrable barrier to further understanding” (Mendelsohn 2013).

The development of new scientific instruments such as MRI and fMRI capable of more safely imaging living brains factored into the United States Congress naming the 1990s “The Decade of the Brain” and Europe declaring the same time span “The Decade of Brain .” At the time neither government committed significant funds to brain studies (Leshner 2013, 533) though more recently that has changed. In 2013 U.S. President Obama’s BRAIN Initiative (Brain Research through Advancing Innovative Neurotechnologies) was allocated US$3billion over ten years and the EU-funded, Human Brain Project, was initiated with a US$1.3billion grant, amidst claims that understanding the brain is “one of the greatest challenges facing 21st century science” (Human Brain Project 2013). In launching these initiatives, advocates have described the human brain as the final frontier of the scientific biological exploration of the human body, largely unknown and under-explored. [quotes are needed here to substantiate your point] The metaphors of the frontier and the pioneer are therefore part of neuroimaging’s mattering process.

Pioneer-related language such as “final frontier” has been used over the last hundred years to describe a wide range of scientific research. As early as 1893, the American historian, Frederick Jackson Turner drew attention to the “Significance of the Frontier in American History”. His 1910 thesis on frontiers (Turner 1910, 2010, unpaginated) included a chapter called, “Pioneer Ideals and the State University” which was based on a Commencement address given at the University of Indiana in 1910. In this he asserts that, “This nation was formed under pioneer ideals. […] The first ideal of the pioneer was that of conquest” before going on to suggest that the “test tube and the microscope are needed rather than the ax and rifle in this new ideal of conquest”. We might now usefully add brain imaging and monitoring technologies to Turner’s list of scientific instruments. Subsequently, scholars have noted the use of pioneer metaphors to argue for the funding of scientific research in nanoscience (Gallo 2008, 266-296), particle physics (Ploeger 2009, 29), space science, and genomics (Ceccarelli 2013) and attributed the popular interest in contemporary neuroscience to the excitement and power associated with a venture successfully marketed as pioneering. The entanglement of pioneer and frontier metaphors with political arguments to garner large amounts of public funding for science research is nothing new, nor is the importance of images to popularize such research. Franklin Roosevelt’s post-world war one science programme invoked the frontier, and U.S. President George Bush used similar rhetoric when talking about space exploration in 1990, to astronomy (Agar 2014), to U.S. President George W. Bush discussing stem cell research in 2001. Each of these major investigations has associated iconic images: placing the U.S. flag on the moon, towering stellar dust clouds from the Hubble Space Telescope, the double helix structure of DNA.

In 1944, Franklin Roosevelt requested a report to steer post-war scientific research from Vannevar Bush, then the director of the U.S. Ofﬁce of Scientiﬁc Research and Development. Roosevelt concluded his letter to Bush with the statement, “[n]ew frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create … a fuller and more fruitful life.” (Bush 1945) This foreshadows subsequent use of pioneer metaphors, and huge American spending, in the areas of neuroscience, the mind, and brain. In his roadmap for postwar scientific research, titled, “Science—The Endless Frontier,” Bush leveraged the marketing power of the pioneer metaphor, ending the letter that accompanied his report by invoking the frontier, “[t]he pioneer spirit is still vigorous within this nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great.” (Bush 1945) As a consequence of the belief that science would serve as a new and lucrative frontier, the U.S. Federal Government was duty-bound to fund basic science over applied science. True to pioneer logic, the specifics of how that money would be spent would largely be left to the scientist-explorers to decide.

Until recently, scholars of history and science communication made only passing reference to the use of pioneer metaphor in science (Agar 2014). But in 2013 rhetorical critic and theorist Leah Ceccarelli published the results of her sustained enquiry into the use of the pioneer metaphor in a range of different scientific research (Ceccarelli 2013). Ceccarelli suggests that each new scientific frontier promises a place for courageous risk-takers to seek their fortunes, to discover that which can be turned to economic gain in the equivalent of a land-grab. Furthermore, she argues that invoking the pioneer resulted in an expectation of, and justification for, these scientists’ relative independence from government control and public oversight (Ceccarelli 2013). In summary, the pioneer and frontier metaphor envisions science as a competition to “plant the flag” on intellectual territory, a zero-sum game of conquest that largely undermines international collaboration between scientists.

<A>Data as image: representations, truth and allure<A>

Neuroimages and brain maps are often described as scientific “representations.” Barad notes that, “representationalism is the belief in the ontological distinction between representations and that which they purport to represent; in particular, that which is represented is held to be independent of all practices of representing” (Barad, 2007). We can see from discussion of the history of the use of photography in the court room (Mnookin 1998, 17) that even in the late 1800s when photography was new, photographic images were positioned as objective and truthful representations of moments in time, of things as they really are, “[t]he photograph is something more than a copy; it is a facsimile, and it is a perfect record of facts, not subject to prejudice, bias, or defective memory.” (Verran v Baird 1889 in Mnookin 1998 18) However, there was a contemporaneous questioning of the veracity of photographs that drew attention to the image and its relation to the apparatus (including the social activities) that was used to produce it, “I need do no more than call to your minds the exaggerations in perspective which are most glaring in architectural subjects taken with a short-focus, wide-angle lens. I do so ... to point out that the position claimed for photography as an infallible exponent of literal truth is quite untenable.” (Croughton, 1886 in Mnookin 1998 21). In both arguments the scientific image, in this case the photograph, “mediates our access to the material world; where they differ is on the question of referent, whether scientific knowledge represents things in the world as they really are (i.e., “Nature”) or “objects” that are the product of social activities (i.e., “Culture”), but both groups subscribe to representationalism.” (Barad, Posthumanist Performativity: 2003, 48) Despite numerous challenges to the photograph’s purported truth status, many scientists continue to use such images unproblematically, perpetuating a belief in representationalism where “subjects” and the photographic “objects” that represent them can be kept separate. This view of the world, and of scientific images, depends on the separation of nature and culture and is based, not on relationality, but on a belief in the ability of science to objectively discover absolute truths.

Neuroimages are usually positioned as authoritative representations, despite being further removed from their referent, the human brain, than a photograph is from its so-called subject, and even though their production depends on more data manipulation than the average production of a photograph. “[L]ike photographs, brain images seem to be simple and straightforward […] images [that] are liable to be mistakenly apprehended as inferentially proximate.” (Roskies 2008, 21) This perceived realism of MRI and other neuroimages is persuasive, arguably in part because “pictorial depth cues such as shading and perspective view give the impression of three-dimensionality.” (Keehner, Mayberry and Martin 2011, 423). The fact that it is commonly known that MRI images, for example, are produced by combining a series of slices of data that represent 3D space reinforces this. The brain image seems to have a greater truth-value than the wet brain. Writing in his bestseller, *Mind Wide Open: Your Brain and the Neuroscience of Everyday Life*, Steven Johnson describes fMRI images as “as close to a pure vision of the mind’s inner life as technology allows us.” (Johnson 2004, 164)

To see an MRI scanner as a brain camera depends on making an observational cut that excludes a more complex and cotangent understanding of the MRI scanner as part of a material-discursive practice. The brain camera analogy obscures the complex processes and relationships that together result in neuroimages. Barad has noted that the ongoing separation of science and the humanities sees humanities as dealing with meaning, values, and culture while science deals with matters of fact, and nature (Barad, Meeting the Universe Halfway*,* 2007). If we diffractively read scientists’ understandings of scientific images, through artists’ understandings of scientific images or humanities scholars’ understandings of them, the same image is likely to be interpreted very differently. Baxandall might put this down to our different gauging skills but however we determine them, the various meanings are the ‘differences that make a difference’ (Barad, Meeting the Universe Halfway 2007, 72).

To suggest that we attend to these differences is not intended as disrespectful to the agency of the image in science, nor to suggest that the meaning that those from the humanities make of the scientific image is “better” or more complete. To do so would perpetuate an ontological separation of science and the humanities that denies their ongoing entanglement. Rather, we suggest photographs and neuroimages emerge through intra-actions between agencies, with no differentiated subject and object. We replace what might be termed ‘subjects’ and ‘objects’ with ‘agencies’ that are never separate, suggesting that no image has a simple truth status, or equally that it has more than one truth depending on the intra-actions through which it materializes, which include who is looking at it, from where and with what intention. This is not the same as suggesting that the image can mean “anything” but encourages closer attention to the intra-action between agencies that brings images into being. The meanings made of the neuroimage continues to emerge as each observer intra-acts and becomes entangled with it.

<A>Agential realism and seductive neuro images<A>

Theorists have drawn attention to the ‘seductive allure’ of neuroscientific explanations of behavior, even explanations not accompanied by images (Weisberg, et al. 2008) suggesting that “logically irrelevant neuroscience information affects people’s judgments of explanations.” Research suggests non-experts are seduced by neuroscientific explanations for behavior, while experts are not unduly swayed by them (Weisberg, et al. 2008, 471). The allure and persuasiveness of neuroimages used in science articles in the popular press, that seem to make scientific results more believable, has concerned scholars and credence has been given to the argument that brain images are key to the appeal of neuroscientific research and the widespread popular (and often partial) dissemination of neuroscientific data (McCabe and Castel 2008). Some scholars of rhetoric have argued against any such phenomenon, pointing to problems with the experiment design used by Weisberg et al and others (Gruber & Dickerson, 2012) to prove the allure of neuroscientific explanations and/or neuroimages. This debate is part of an emergent ‘neuroskepticism’ (Rachul and Zarzeczny 2012) that developed over a decade, amid concerns about functional neuroimaging, including methods used, interpretation of results and ethics related to human subjects.

Neuroethicists argue that neuroimages are highly persuasive when presented as proof of a particular neuroscientific explanation or theory, despite the fact that the methodology behind the experiments that produces the images is inadequately communicated to the public “resulting in a dramatic asymmetry in conceptual understanding between the scientists who conduct the experiments and the public to whom findings are communicated.” (Neely 2011) Why is there this mismatch? Steven Petersen suggests that “[t]he problem right now with imaging is that doing experiments right is really, really hard, but getting pictures out is really easy” (Petersen in Steger and Arnold 2008). Others, like Michelle Neely, have taken this further and argued for an evaluation of what she terms “the deceptive nature of the neuroimage *per se”* (Neely 2011, 2)*.* Findings that show experts’ interpretation of explanations and images differ from novices conform to Baxandall’s theory of “gauging” and suggests not that neuroimages are, as Neely suggests, inherently deceptive (or any *more* inherently deceptive than a photograph) but rather that they are understood differently by different people and at different times. Using the example of fifteenth century merchants who are skilled in gauging volume because they dealt in barrels, Baxandall draws our attention to individual’s specific powers of discrimination, the particular learned ways of looking that are associated with people’s professions. “One has to learn to read [those images], just as one has to learn to read a text from a different culture, even when one knows, in a limited sense, the language: both language and pictorial representation are conventional activities.” (Baxandall 1988, 152) If we apply Baxandall’s ideas to neuroscientists who have developed visual acuity in relation to brain images it is not surprising that those images have less ‘allure’ and are interpreted differently by experts used to reading them. Somewhat in keeping with this, rather than dismissing neuroimages, Gruber et al argue for a “an engagement with neuroscience […] built as much as possible on cooperation and mutual exchange” (Gruber, Jordynn, et al. 2011) and this is echoed by the co-authors Jordynn Jack and Gregory Appelbaum (Jack & Appelbaum, 2010), respectively a rhetoric-of-science scholar and a neuroscientist. In summary, scholars interested in the rhetoric of neuroscience have called for more research into how brain scan technologies, and the image data they produce, “are applied and interpreted” (Gruber, Jordynn, et al. 2011, 4).

How might neuroimages be differently understood if viewed using Karen Barad’s concept of agential realism? Agential realism uses “analogies from quantum physics to re-conceptualise the practices and processes through which scientific ‘objects’ and knowledge are created. Agential realism rethinks agency within scientific practices demanding that we understand how the apparatus of science […] are formed through practices.” (Prophet and Pritchard, Performative Apparatus and Diffractive Practices 2015, 3) For example, the practice of using fMRI to observe and document the brain activity of a living human subject who is inside a scanner and looking at a representation of a memento mori painting is one apparatus of science. “According to agential realism, knowing, thinking, measuring, theorizing, and observing are subjective material practices of intra-acting within and as part of the world.” (Barad, Meeting the Universe Halfway 2007, 90). Barad’s causality goes beyond the simple combination of classical options often presented in the humanities and science debate, that “there is, on the one hand, absolute freedom in our choices of apparatus, and, on the other strict deterministic causal relationships” (Barad, Meeting the Universe Halfway 2007, 130). This is useful when considering the apparatus of neuroimaging, where for example, there is no absolute freedom over which technology to use to image the living brain, we have very limited choices. Barad’s particular definition of the term “apparatus” is important here. For Barad, apparatuses are not simply machines, equipment or mediating devices, but include processes as well as many other forces both material and immaterial (funding policies, experiment protocols, MRI hardware, software, team structures, publishing norms). The processes that emerge from the arrangement of these human and nonhuman material-discursive forces are those commonly referred to as “scientific,” those referred to as “social” and, I suggest, those referred to as “artistic.”. Neuroimages come into being performatively through these processes and their meanings continue to emerge as they are interpreted. Agential realism proposes a positive conversation between the disciplines that might have, for example, conflicting theories of the mimetic qualities of photographs, and is therefore a useful framework for reconsidering neuroimages given the conflicting positions taken by scholars described above.

<A>Conclusion<A>

fMRI images are derived from neural activity that is not visible. Such activity is made visible via a series of intra-actions and processes that transform the neural activity into data that is then translated into an image. The MRI scanner is one agent in this apparatus, and importantly it does not directly measure neuronal activity in the way that MEG and EEG machines do, rather MRI records changes in blood flow. Once the MRI scanner has produced an image, image processing techniques are used to mitigate the noise in those images. The so-called “noise” is a trace of the intra-action of whole human subjects and their environment. The requirement to remain very still for five to ten minutes, controlling micro-movements of one’s body, is quite difficult for many people and the sense of being embodied is unusually amplified as one tries to control (and becomes hyper-aware of) what are usually unconscious bodily functions like breathing or swallowing. But to lose control and move is to add noise to the data and the most scientifically useful MRI image emerges through intra-actions that partially erase the trace of the embodied human who might have moved their head “due to swallowing, fidgeting, overt speech, or transmitted motion as a result of finger pressing on a keypad [… which] are a major cause of inconclusive or uninterpretable fMRI results in the clinical setting”. (Desmond and Chen 2002, 483)

New materialism suggests that there might be much to be gained by seeing the “agencies” that include humans, pioneer-themed rhetoric, neuroimaging instruments, computational processes and neuroimages as constantly emerging through intra-actions. This approach moves beyond a critique of neuroimaging and calls our attention to the relationships between agencies that bring neuroimages into being. Taking the agential realist idea of intra-action, in contrast to interaction, assumes that distinct bounded agencies do not precede any such relating but rather that agencies emerge *through* a process of relating. Intra-action supposes that the neuroimages I am part of emerge through the process of relating to pioneer metaphors, the machinations of state and corporate funding, gender, the future exhibition of the objects in a museum and more. Furthermore, intra-actions with the protocols of MRI and neuroscience research, ranging from experiment design, to data interpretation “norms” performatively produce those images. By taking a new materialist approach to understanding neuroimages, I am arguing for a “diffractive art practice” (Prophet and Pritchard, Performative Apparatus and Diffractive Practices 2015, 13) — an entangled collaboration between artist, neuroscientists, MRI scanners, software and the art world that attends to the complex relationships from which neuroimages and 3D art objects emerge.

# Bibliography

Agar, John. *Science and Spectacle: The Work of Jodrell Bank in Postwar British Culture.* Routledge, 2014.

Ahmed, Sara. "Open Forum Imaginary Prohibitions Some Preliminary Remarks on the Founding Gestures of the New Materialism." *European Journal of Women's Studies* 15, no. 1 (2008): 23-39.

Asberg, Cecilia and Lykke, Nina. "Feminist Technoscience Studies." *European Journal of Women's Studies* (Sage) 4, no. 17 (2010): 299-305.

Barad, Karen. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning.* Durham, NC: Duke University Press Books, 2007.

Barad, Karen. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter." *Signs: Journal of Women in Culture and Society* (The University of Chicago) 28, no. 3 (2003): 801-831.

Barad, Karen. "Quantum Entanglements and Hauntological Relations of Inheritance, Dis/continuities, SpaceTime Enfoldings, and Justice-to-Come,." *Derrida Today* 3, no. 2 (2010): 240—268.

Baxandall, Michael. *Painting and experience in fifteenth century Italy: a primer in the social history of pictorial style.* Oxford: Oxford University Press, 1988.

Bush, Vannevar. "Science: The endless frontier: A Report to the President." *national Science Foundation.* Transactions of the Kansas Academy of Science. 07 1945. https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm (accessed 05 01, 2015).

Ceccarelli, Leah. *On the frontier of science: An American rhetoric of exploration and exploitation.* Michigan State University Press, 2013.

Clark, Andy. "Pressing the Flesh: A Tension in the Study of the Embodied, Embedded Mind?" *Philosophy and Phenomenological Research* 76, no. 1 (2008): 37-59.

Desmond, John E, and Annabel S. H. Chen. "Ethical issues in the clinical application of fMRI: factors affecting the validity and interpretation of activations." *Brain and cognition* 50, no. 3 (2002): 482-497.

d’Inverno, Mark and Prophet, Jane. "Biology, Computer Science and Bioinformatics: Multidisciplinary Models, Metaphors and Tools, Multidisciplinary Investigation into Adult Stem Cell Behaviour, LNCS Transactions on Computational System Biology." In *Lecture Notes in Artificial Intelligence*, by Pablo Gonzalez Andrea Omicini. Springer, 2006.

Dolphijn, Rick, and Iris van der Tuin. "New Materialism: Interviews & Cartographies." *Open Humanities Press.* An imprint of Michigan Publishing. 2012. http://quod.lib.umich.edu/o/ohp/11515701.0001.001/1:4.3/--new-materialism-interviews-cartographies?rgn=div2;view=fulltext > (accessed 05 01, 2015).

Fine, Cordelia. "Is there neurosexism in functional neuroimaging investigations of sex differences?." *Neuroethics* 6, no. 2 (2013): 369-409.

Fitzgerald, Des, and Felicity Callard. "Social science and neuroscience beyond interdisciplinarity: experimental entanglements." *Theory, Culture & Society* 32, no. 1 (2014): 3–32.

Francisco J. Varela, Eleanor Rosch, Evan Thompson. *The Embodied Mind: Cognitive Science and Human Experience .* Cambridge, MA: MIT Press, 1992.

Frazzetto, Giovanni, and Suzanne Anker. "Neuroculture." *Nature Reviews Neuroscience* 10, no. 11 (2009): 815-821.

Gallo, Jason. "Speaking of science: The role of the National Science Foundation in the development of United States information infrastructure." Northwestern University, USA. 2008. http://search.proquest.com/docview/304503128 (accessed 05 01, 2015).

Gibbs, Graham. *Learning by Doing: A guide to teaching and learning methods.* Oxford: Further Education Unit, Oxford Polytechnic, 1998.

Gombrich, Ernst H. *Art and Illusion: A Study in the Psichology of Pictorial Representation.* Vol. 5. Princeton University Press, 1960.

Gries, Laurie E. "Iconographic tracking: A digital research method for visual rhetoric and circulation studies." *Computers and Composition* 30.4 (2013): 332-348.

Gruber, David, and J Dickerson. "Persuasive images in popular science: Testing judgments of scientific reasoning and credibility. Public Understanding of Science, 21 (8), DOI:10.1177/096366251245407." *Public Understanding of Science* 21, no. 8 (2012): 938-948.

Gruber, David, Jack Jordynn, Lisa Keranen, John M McKenzie, and Matthew B Morris. "Rhetoric and the neurosciences: Engagement and exploration." Poroi 7, no. 1 (2011): 11." *Poroi An Interdisciplinary Journal of Rhetorical Analysis and Invention* 7, no. 1 (2011): 3-12.

Hammarström, Matz. "(Mis) understanding Intra-active Entanglement–Comments on René Rosfort’s Criticism of Karen Barad’s Agential Realism." *Kvinder, Køn og Forskning*, no. 4 (2012).

Hirst, Damien. "A Thousand Years." *Damien Hirst Website.* 1990. http://www.damienhirst.com/a-thousand-years (accessed 05 01, 2015).

*Human Brain Project.* 2013. https://www.humanbrainproject.eu/discover/the-project/overview (accessed 05 01, 2015).

Jack, Jordynn, and Gregory L Appelbaum. "This is Your Brain on Rhetoric: Research Directions for Neurorhetorics." *Rhetoric Society Quarterly* 40, no. 5 (2010): 411-437.

Jackson, Robert. "Making the Digital Divide Cheap and Nasty." *Furtherfield Features.* 2012. http://www.furtherfield.org/features/articles/making-digital-divide-cheap-and-nasty (accessed Janurary 28, 2014).

Jane Prophet & Mark d'Inverno. "Creative conflict in interdisciplinary collaboration: interpretation, scale and emergence." *Interaction: systems, theory and practice.* Creativity and Cognition Studios, 2004. 251-270.

Johnson , Steven. *Mind wide open: Your brain and the neuroscience of everyday life.* Simon and Schuster, 2004.

Jordan, John W. "Kennedy's romantic moon and its rhetorical legacy for space exploration." *Rhetoric & Public Affairs* 6, no. 2 (2003): 209-231.

 Josipovic, Zoran. "Duality and nonduality in meditation research." *Consciousness and cognition* 19, no. 4 (2010): 1119-1121.

Keehner, Madeleine, Lisa Mayberry, and Martin H Martin. "Different clues from different views: The role of image format in public perceptions of neuroimaging results." *Psychonomic bulletin & review* 18, no. 2 (2011): 422-428.

Keevers, Lynne and Treleaven, Lesley. "Organizing practices of reflection: a practice-based study." *Management Learning,* 42, no. 5 (2011): 505-520.

Leshner, Alan I. "Seize the neuroscience moment." *Science* 342, no. 6158 (2013): 533-533.

McCabe, David P, and Alan D Castel. "Seeing is believing: The effect of brain images on judgments of scientific reasoning." *Cognition* 107, no. 1 (2008): 343-352.

Mendelsohn, Fred. "Understanding the brain and mind: science’s final frontier?" *Medicine, Denistry, Health Science.* University of Melbourne. 10 4, 2013. http://mdhs.unimelb.edu.au/news/understanding-brain-and-mind-science%E2%80%99s-final-frontier (accessed 05 01, 2015).

Mnookin, Jennifer L. "Image of Truth: Photographic Evidence and the Power of Analogy." (Yale Journal of Law and the Humanities) 10, no. 1 (1998): 1-73.

Neely, Michelle. "A Neuroimage is Worth a Thousand Transformations: The Deceptive Epistemic Value of Neuroimagery." *Technology and Society* (Intersect: The Stanford Journal of Science) 4, no. 11 (2011): 1-7.

Ninković, Pavel. "In search of the period eye: Contributions from neuroscience." University of London Birkbeck. 2010. https://www.academia.edu/380051/In\_Search\_of\_the\_Period\_Eye (accessed 05 01, 2015).

Obama, Barack. Tweet [10:24 AM - 2 Apr 2013](https://twitter.com/BarackObama/status/319093103543869440). https://twitter.com/BarackObama/status/319093103543869440

Obama, Barack. “Remarks by the President on the BRAIN Initiative and American Innovation”. https://www.whitehouse.gov/photos-and-video/video/2013/04/02/president-obama-speaks-brain-initiative-and-american-innovation#transcript

Ploeger, Joanna S. *The Boundaries of the New Frontier: Rhetoric and Communication at Fermi National Accelerator Laboratory (Studies in Rhetoric/Communication.* University of South Carolina Press, 2009.

Pritchard, Helen, and Jane Prophet. "Diffractive Art Practices: Computation and the Messy Entanglements between Mainstream Contemporary Art, and New Media Art." *Artnodes* 15 (2015).

Prophet, Jane. "Sublime Ecologies and Artistic Endeavors: Artificial Life and Interactivity in the Online Project." *Leonardo* (MIT press), 1996: 339-344.

—. *Technosphere, Jane Prophet, .* 2002. http://web.archive.org/web/20020625224810/www.heritageinterpretation.org.uk/journals/j2a-tech.html (accessed 06 01, 2014).

Prophet, Jane. "the Artist in the laboratory: co-operating (t) reasonably." *Artnodes*, no. 11 (2011).

Prophet, Jane, and Helen Pritchard. "Performative Apparatus and Diffractive Practices: an account of Artificial Life art." *Artificial Life* (MIT press) 21, no. 3 (2015): 1-13.

Prophet, Jane, and Mark d'Inverno. "Creative conflict in interdisciplinary collaboration: interpretation, scale and emergence." *Interaction: systems, theory and practice.* Creativity and Cognition Studios, 2004. 251-270.

Prophet, Jane, and Mark d'Inverno. "Transdisciplinary Collaboration in CELL." In *Aesthetic Computing*, edited by Paul A.Fishwick, 185-196. MIT Press, 2008.

Prophet, Jane, d’Inverno,Mark. "Transdisciplinary Research in CELL." In *Aesthetic Computing*, edited by Paul Fishwick. MIT Press, 2006.

Rachul, Christen, and Amy Zarzeczny. "The rise of neuroskepticism.: 77-81." *International journal of law and psychiatry* 35, no. 2 (2012): 77-81.

Racine, Eric, Ofek Bar-Ilan, and Judy Illes. "fMRI in the public eye." *Nature Reviews Neuroscience* 6, no. 2 (2005): 159-164.

Rainko, Ashleigh Kathleen. "The Scientific Frontier within Presidential Appeals to Science." (2015). https://wakespace.lib.wfu.edu/bitstream/handle/10339/57140/Rainko\_wfu\_0248M\_10716.pdf

Roskies, Adina L. "Neuroimaging and inferential distance." *Neuroethics* 1, no. 1 (2008): 19-30.

Snell, Ted. *Online Exhibition catalogue for Memento Mori.* 2014. http://www.lwgallery.uwa.edu.au/exhibitions/past/2014/mementomori/catalogue (accessed 05 01, 2015).

*TechnoSphere .* http://en.wikipedia.org/wiki/TechnoSphere.

Theise, Neil. *Neil D. Theise, MD.* 2015. http://www.neiltheise.com/ (accessed 05 01, 2015).

Turner, Frederick Jackson. *The frontier in American history.* 1910, 2010.

"Verran v Baird." Boston, Mass: Supreme Judicial Court Records, Social Law Library, , 1889.

Unknown. "Wax model of a female head depicting life and death." Science Museum. *On loan to the Wellcome Trust, Medicine Man exhibition, 'End of Life' case (K17) Object number:A99821.* London: Acquired from Born-Traub, 1701-1800.

Vanderbilt University Fine Arts Gallery website. Memento Mori - Looking at Death in Art and Illustration (March 12 - May 23, 2015). http://www.vanderbilt.edu/gallery/season.php (accessed 08 10, 2015)

Vessel, Edward A., Gabrielle Starr, and Nava Rubin. "The brain on art: intense aesthetic experience activates the default mode network." *Frontiers in human neuroscience* 6 (2012): 1-17.

Weber, Jutta. "From science and technology to feminist technoscience." In *Handbook of Gender and Womens Studies*, 397-414. London: Sage, 2006.

Weisberg, Skolnick, Deena, Frank C Keil, Joshua Goodstein, Elizabeth Rawson, and Jeremy R. Gray. "The seductive allure of neuroscience explanations." *Journal of cognitive neuroscience* 20, no. 3 (2008): 470-477.

Whitaker, Randall. "Exploring and employing autopoietic theory: Issues and tips." *In Biology, Language, Cognition and Society: International Symposium on Autopoiesis.* Belo Horizonte, Brazil, 1997.