Enchantment by Neurosensing through a Historical & Critical Lens

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Abstract: We explore a the concept of enchanting technologies by establishing their presence throughout history, particularly in the examples of electricity and radio, and the status of neurosensing and neuroimaging as an enchanting technology unfolding today. In our historical analysis and application to neurosensing we unearth themes present in enchanting technologies including a poor understanding of its workings, their position of modernity and prestige, the misuse of the technology by scientists and consequential over-inflated expectations generated by hyped media reporting, and their use of underlying contemporary mechanisms to prey upon our hopes and fears. We also describe some examples of misappropriation of neuroimaging in other fields, and how this is facilitated by the use of images in particular. Finally, we present two critical design pieces intended to promote consideration by viewers on neurosensing technologies and how the data they collect is used and presented.

Enchantment in History

"What is important is not what the object *is* but what it promises to do."[1] This is how Ames describes the concept of a charismatic technology, "the material form of a charismatic technology is less important than how it invokes the imagination."[1] We will further this definition through our own keyword of enchantment, moving beyond the technologies' charisma to their ability to cast a spell upon us, beguiling us into believing their lofty promises while blinding us to more realistic and ultimately more valuable studies and implementations. We will look at enchantment through historical examples of the emergence of electricity and radio while simultaneously drawing parallels to the unfolding methods of neurosensing in neuroscientific research and publicization today. Through this historical lens and our own criticality-inspired design ideas, we hope to help "break the spell of the present"[2] as William Stahl puts it, and reveal the current hype around neuroscience as yet another round of enchantment by technology.

For enchantment to exist and persist, the technology being introduced must be one that is poorly understood at its outset. This unknown air of mystery affords the technology with the ability to take any shape a person may imagine, regardless of its true potentials and inherent limitations. In the early 19th century the railroad, for example, "was implicated in dozens of hyperbolic claims, including the 'annihilation of space and time' with its sustained speed'"[1]. Later that century the advents of electricity and radio brought with them their own perceived magical properties in the wake of general ignorance of their actualities. As David Nye discusses in his book *Electrifying America: Social Meanings of a New Technology, 1880-1940*, "the average citizen had a slender practical understanding of electricity, and grasped it only in the general sense as a mysterious new energy source that would make everything better."[3] This overall general misunderstanding not only led to positive claims but to unfounded fears as well, "[...] an old woman lived the latter years of her life in the horrible suspicion that electricity was dripping all over the house. 'It leaked, she contended, out of empty sockets if the wall switch had been

left on.'"[3] In *Listening In: Radio and the American Imagination* Susan Douglas surfaces similar early beliefs and fears about radio at its inception in the U.S., "Another [listener] remembered when his uncle showed a neighbor that the radio was not connected to any wires, then turned the set on: the neighbor 'ran as if black magic would get him'."[4] These examples highlight the perceived magical and limitless nature of these technologies primarily due to the lack of a fundamental understanding of how they function. To achieve this status the technology in question must be novel enough that prior experience does not outright elucidate its capabilities and limitations. A modification of an existing technology or one that relies heavily on a previously well-known one to achieve its worth would not likely be a candidate for enchantment. Cellular phones, for example, while they were a significant technological advancement, draw heavily upon the same scientific explanation as the telephone which had been around and in use for almost a century when its cellular version was first introduced, partially demystifying their potential.

In parallel, neuroimaging, especially the most recent and now widely spread technique of functional magnetic resonance imaging (fMRI) is groundbreaking in its apparent revealing of the workings of the human brain in response to a variety of stimuli. In *Brainwashed: The seductive appeal of mindless neuroscience* the authors, Satel and Lilienfeld, warn of this trend, "It's all too easy for the non expert to lose sight of the fact that fMRI and other brain-imaging techniques do not literally read thoughts or feelings."[5] By presenting brain imaging results as colorful bright spots overlaid on anatomically detailed brain models, uninitiated consumers of neuroscientific research are easily tricked into believing that the imaging technology can blatantly discern thoughts from a visualization of differing magnetic signatures. This tendency is explored directly in a study conducted at McGill University[6] in which participants, including those who were educated in the limitations of neuroimaging, were placed in a faux brain scanner whose results claimed to decipher their internal thoughts. The study found that most students, including those in the neuroscience-educated group, were very likely to believe the results of the scanner. The authors cited a phenomena called "vividness" as a potential culprit, the idea that " a single compelling experience can override multiple scientific accounts, instigating faith in erroneous ideas."[6] These results were echoed in a survey we conducted that focused on questions surrounding brain-computer interfaces, which generally make use of electroencephalogy (EEG) as opposed to fMRI to detect brain activity. When shown a photo of a medical EEG cap in use and asked how they thought the technology works, half of the 24 respondents provided nonsensical or unfounded ideas, most of which didn't even venture a guess simply responding with "don't know" or "not sure". Furthermore, an image of a consumer grade device on the market, which for marketing reasons attempts to hide its inner workings, generated 13 completely inaccurate responses. In our sample that was, if anything, bias toward more neuroscience-educated individuals with 30% reporting previous work or educational experience in the field, there was a clear systematic misunderstanding of the technology's scientific basis, leaving ample room for enchantment to take hold and propagate far-fetched ideals and potentials.

While an enchanting technology will be poorly understood at its outset, an air of prestige and modernity also surrounds it, luring people to want to associate themselves with it to heighten their own status to its perceived level. Nye writes of this phenomenon with electricity, “The popular faith in electrical medicine, like the vogue in electrical items of dress, was a sign of the prestige of the new technology. People wanted to commingle with it and draw upon its power.”[3] Douglas mentions a similar pattern with radio when scientists became celebrities as people clamoured to hear about the capabilities of the new technology, “This was when certain scientists, inventors, and explorers were international celebrities, lionized in the press and admired by millions [...] when Sir Oliver Lodge spoke to sellout crowds in places like Carnegie Hall not about atoms or electromagnetism but about séances, mediums, and communicating with the dead, it was big news.”[4] In this case, the vouching for the technology and its abilities by a renowned scientist furthered its modern appeal, we will explore this trend further later on.

The case of neuroimaging in neuroscience is no different, the allure of seemingly concrete imagery to explain something as complex and mysterious as the brain is seductive and is used to lend false objectivity and power to those that make use of “brain data”. This is evident in the numerous “train your brain” games available for computers and mobile devices, citing neuroscience research findings and images as the factual basis for their “guaranteed” results. Scientists themselves are subject to this allure, often forced to make use of it in a system where publications, news headlines, education opportunities, and academic job positions are highly competitive. Satel and Lilienfeld discuss this happening in psychology departments at research universities, “...expertise in imaging technology is becoming a sine qua non for graduate students in psychology programs, increasing their odds of obtaining federal grants and teaching posts and boosting the acceptance rates of their papers by top-flight journals.”[5] Students in the field of psychology, which has existed and produced groundbreaking research long before the advent of neuroimaging, are now hard pressed to utilize imaging techniques instead of or at least in conjunction with other psychological research methods in order to be a part of what is considered the “cutting-edge” of brain and behavior studies.

This pressure to use enchanting technologies in research may certainly be useful and even necessary in the eventual discovery of their true properties, however with a public perspective that the capabilities are limitless scientists often propagate enchantment in their own work. Their motivation being to garner attention and fame which comes with it publications and funding. Thomas Edison was guilty of this in his work with electricity as Nye discusses, “Even as he invented the technical details of the electrical generation and distribution system, Edision expressed utopian ideas about its uses, he predicted that the electrification of the home would eliminate distinction between night and day [and] constant light might lead to the elimination of sleep.”[3] This trend with Edison didn’t end with electricity, he comes up in Douglas’s work with radio as well, “Thomas Edison, never one to be left out of the media spotlight, gave an exclusive interview to the American Magazine announcing that he was developing ‘an apparatus designed to enable those who have left earth to communicate with those of us who are still on earth.’ The device would be based, he assured readers, on ‘solid scientific methods’.”[4] These examples with Edison’s advertisement of his own work highlight the

tendency by scientists themselves, those who the public look to for sound and empirical observations, to over inflate expectations or draw spurious conclusions to satisfy either themselves or their stakeholders. These works by scientists are then escalated to an even further level of abstraction and simplification by the media, ensuring that even the works of those intending only to report their findings modestly are caught up in the frenzy. “As usual,” Douglas writes of the first studies of radio, “press magnified the phenomenon and our semi-hysterical generation hastened to see and hear the latest novelty.” citing a specific case she quotes, “Noting that ‘we are playing on the shores of the infinite’, Joseph K. Hart wrote in the Survey ‘The Most occult goings-on are about us. Man has his fingers on the triggers of the universe.”[4]

This pattern of researchers prematurely stating causational conclusions and the media all too eagerly cutting corners in their publicization is not exclusive to these historical examples. Neuroscientists too at times contribute to the mania surrounding brain science with far-fetched claims. Satel and Lilienfeld cite an example, “According to neuroscientist Sam Harris, inquiry into the brain will eventually and exhaustively explain the mind and, hence, human nature. Ultimately, he says, neuroscience will - and should dictate human values.”[5] These claims do not go ignored by the press the authors detail, “...in a world where university press releases elbow one another for media attention, it’s often the study with a buzzy storyline (“Men See Bikini-Clad Women as Objects, Psychologists Say”) that gets picked up and dumbed down.”[5] This contributes to a concept the authors refer to as “neurocentrism”, a highly problematic view in terms of guiding research and treatment, which we will come across again later on.

Finally, the most difficult to perceive and measure but perhaps the true driving force behind enchanting technologies is the existence of an underlying contemporary problem or mindset that the technology is connected to in some way and is purported to address. The most readily observable case is that of radio’s initial perceived ability to commune with the dead connecting with the concurrent events of World War I, one of the bloodiest periods in human history. Douglas notes this connection, “Observers at the time cited the same obvious reason for the fervor: the hideous, senseless carnage of the Great War.... affirmation of an afterlife, especially by men of science, was, at least for some, reassuring and even exhilarating.”[4] Ames, in her discussion of the charisma of the One Laptop Per Child (OLPC) project draws a similar connection with modern and perhaps more subtle underlying desires attached to computers, “The stories OLPC tells about the potentials of its charismatic laptop roll into one package many of the promises connected to computers and cyberspace: of newfound freedoms and potentials for computer-based self-governance, of the inversion of traditional social institutions.”[1] In both this and the case of radio, the technology is turned to to single-handedly address the hopes and fears of individuals seeking explanation or solutions to complex or impossible problems.

While it is difficult to see these underlying drivers as they are exerting their influence in the present, we hypothesize that a similar connection between neuroscience research and the desire to explain, cure, and “solve” the mind and brain exists today, central to its enchantment. “How [the brain] gives rise to subjective feelings is one of the greatest mysteries of science and

philosophy."[5] write Satel and Lilienfeld, surfacing what we may be projecting onto the lit up pictures of brains we're presented with. In our survey, when asked if and how respondents felt brain sensing technologies will benefit society in the future, many of the hopeful responses were centered around diagnosing and treating brain diseases and neurological conditions, one respondent stated that they "think [brain sensing technologies] will have a massive impact on the way that we understand neurological conditions, especially the neural basis of mental health, which is only going to be a growing problem in an ever more connected society." Even those respondents that did not agree the technologies would be beneficial stated dystopic concerns about their use in the future such as "....an invasion of privacy being able to read anyone's thoughts" or "enabling government authorities to probe people's minds without consent". These fears appear to be a nod toward the "big brother" culture prevalent in many criticisms of technologies containing cameras, microphones, and other sensors that are becoming commonplace today.

Enchanted Practices

As fields outside of neuroscience increasingly adopt neuroimaging into their practices, they risk becoming enchanted with neuroscience's imagery and promises as well. Education, law, and psychiatry are three examples of fields that have used neuroimaging to inform their practices, sometimes with criticism from the neuroscience community.

In the case of law, companies such as Millennium Magnetic Technologies offer fMRI scans intended to make objective the "subjective experience" of pain[7]. Victims suing for liability have used these images to settle outside of court, in spite of limitations identified by neuroscientists. For example, individuals may be able to cheat the test by imagining pain, and pain manifests differently in each individual, making a baseline difficult to establish. Moreover, reverse inference of areas activated under pain may lead to false conclusions about what caused the activity. University of Colorado neuroscientist Tor Wagner even suggests that without understanding the comparing a subject in pain to a control, and without understanding the biological mechanism, "it's like reading tea leaves."[7]

Neuromyths that emerge from misinterpretations of imaging also influence education practice. For example, fMRI scans that show a lateralized brain function and subtract the baseline activity level "as reproduced in popular and accessible articles, can promote the idea that there are isolated functional units".[8] Taken out of context, they can also be used to perpetuate the myth that individuals are either "right brained" or "left brained". This myth influences teachers to treat students differently.[8]

Neuroimaging has also increasingly influenced psychiatrists and patients' understanding of mental disorders. For the former population "the rapid advances of neuroscience are being hailed by many as finally offering a biological paradigm that will not merely augment, but potentially replace, traditional psychiatry".[8] In contrast to current psychiatric practice, which relies on an individual interpretation of a collection of behavioral and social cues, identifying the

biological cause of the disease can appear to be a more “scientific”[8], and more attractive alternative.

For patients, the shift to a biological understanding of disease has the potential to both damage and benefit. The therapeutic benefits from the rise of usage have been largely neutral, since it has led to few major treatments impacting lifespan or disease prevalence over the last two decades.[5] However, neuroimaging places emphasis on the biological basis and potential cures for a disease, “discouraging the view that a person’s traits are importantly shaped by ecological conditions”.[8] Additionally, an oversimplified presentation of PET scans can suggest a false binary between the “schizophrenic brain” and the “normal brain”, “even though there are many people diagnosed with schizophrenia whose brains look like those of people without, and people without schizophrenia whose brains look like those of people with it”.[8] This can exacerbate a sense of “otherness” between schizophrenic patients and people without schizophrenia.

However, at the same time, neuroimaging can give patients a tool to understand and explain their nature even while it does not yield the cures hoped for.[8] In a study of the use of neuroimaging by psychiatric patients, “Almost unanimously, they express the idea that evidence of something physical would not only demonstrate to themselves that the condition, as most put it, is “real,” but more importantly that the neuroscientific confirmation could be used to address problems and anxieties that arise in relation to other people.“[8] The image of their brain becomes a tool to explain their experience to their friends and family.

The tendency to view a patient’s condition in terms of their fMRI scans represents part of a larger trend towards neurocentrism, or “the view that human experience and behavior can be best explained from the predominant or even exclusive perspective of the brain”.[5] The examples from law and education also follow this pattern. However, in spite its aura of scientific objectivity, neurocentrism is not values neutral, as “ideas, hopes, methods, and institutions”[8] will influence “what will count as facts about the brain”.[8] Understanding how images and facts in particular are constructed and consumed can expose some of these values implicit in the neurocentric mindset.

The Power of Brain Imaging

Two mechanisms in particular influence the creation and perception of brain imaging, and contribute to a neurocentric approach to human existence. The first is what Hayles names the Platonic backhand, or “inferring from the world’s noisy multiplicity a simplified abstraction”.[10] The second is the myth of the photographic truth, which Joyce examines in *Magnetic Appeal.*

Hayles’ *How we Became Posthuman* provides a framework for understanding the relationship between a brain scan and the brain itself. It fits within the Western tendency to “privilege[] the abstract as the Real and downplay the importance of the material instantiation.”[10] The appeal of the abstract form comes from its perceived liberation from a material expression and freedom “to travel across time and space”.[10] The value placed on the abstract comes

across even in language used in neuroscience media, which often “collapse distinctions between the flesh and the image.”[11] Hayles argues that the “abstract patterns can never fully capture the embodied actuality, unless it is as prolix and noisy as the body itself,”[10] and that in fact the abstract representation may become abstracted to the point of uselessness. An example is in fMRI studies, which require a single average of many individual experiences. Figure 1 demonstrates how this process of abstraction erases individual differences and suggests symmetrical activation that does not occur in any one subject.

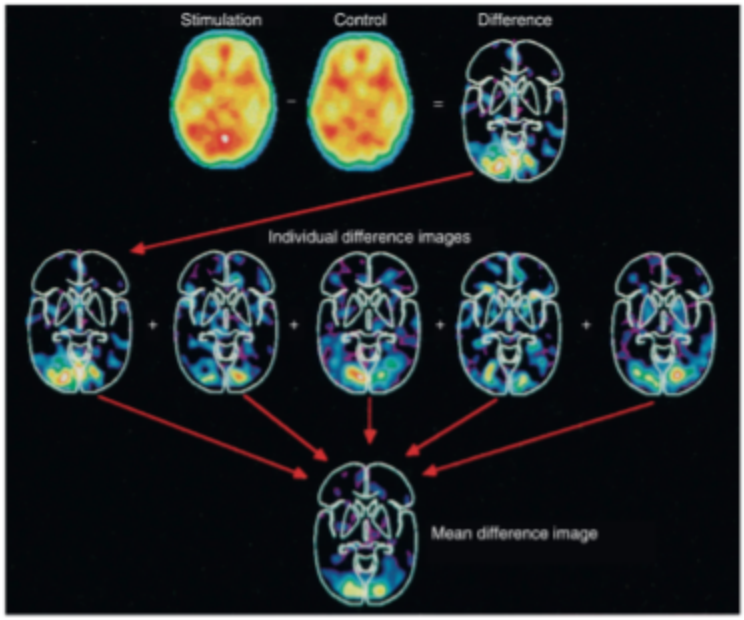


Figure 1: PET scans illustrating the subtraction and averaging processes. From *A Critical Neuroscience.*

The product of a brain scan, a single image of a partially illuminated brain, belies the reality that “even saying that the final images are “constructed” largely fails to address just how much work is done in order to achieve the final images.”[8] Joyce hypothesizes that the reason that scientists, the media, and the public escalate the single interpretation is due to the mechanic origins of the image, and cultural beliefs that photographs are unmediated representations of the physical world.[11] However, in reality, perception of images arise from the series of decisions made during the preparation of the image, the individual background, and additional framing (for example, in *Empirical Neuroenchantment*). Hayles’ and Joyce’s work suggests that enchantment can be tempered with a greater comfort with the messy reality of the materiality of brains and scientific practice.

Conclusion

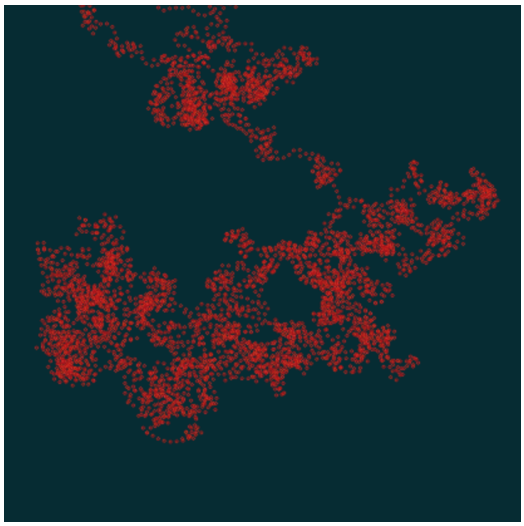
As we've shown, enchantment by emerging technologies is not an isolated event, but a motif that has repeated itself throughout history, each time captivating audiences with initial dazzling spectacle. We concede that it is logical for something new and unknown to pique our interests and our imaginations. However, we hope that by recognizing this as merely shock value we can engender a healthy skepticism to not overstate the capabilities of technologies and thus detract from their true utility. Research in neuroscience, and specifically neuroimaging, is often presented in an enchanting light which already is showing its far-reaching consequences. Comfort with the materiality of the brain and science itself can help resist the negative consequences of enchantment and positively guide the values of neurocentrism.

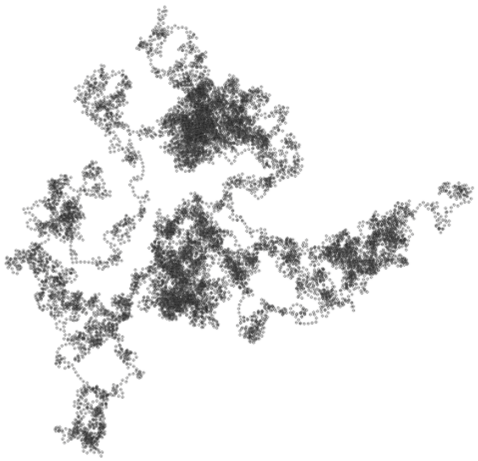
Design Pieces

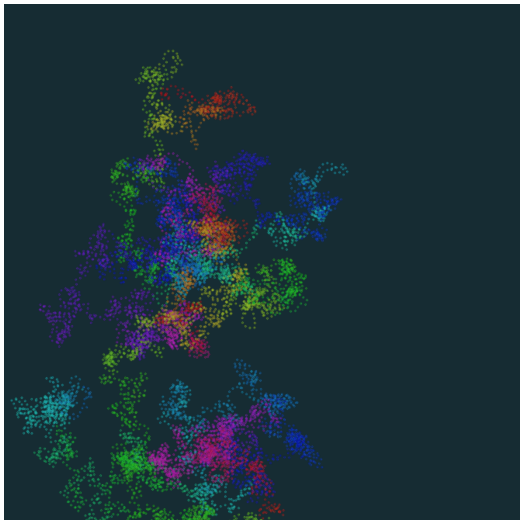
Design 1 - fMRI Traces

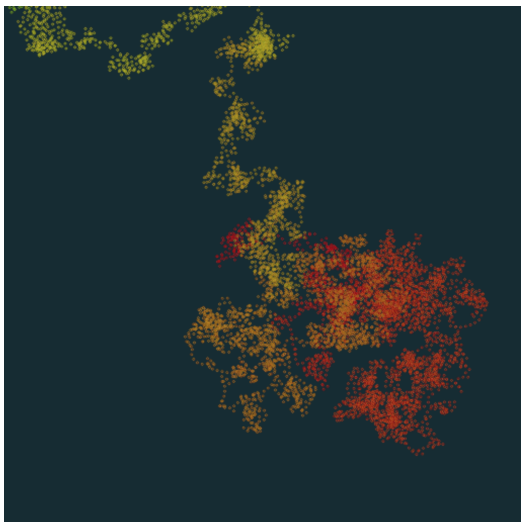
Motivation: This is a critical design piece intended to contrast a fMRI scan reconstruction. I was inspired by two observations. First, multiple authors we read who compared interpreting fMRI scans without the proper context to "reading tea leaves". Second, a lot of processing happens to create images from the scan, and some of that manipulation is motivated by aesthetics. With this design, I want to isolate the enchanting features that can arise from manipulating a set of data, and hopefully cause the viewer to reflect on how visual representations can become removed from the underlying data.

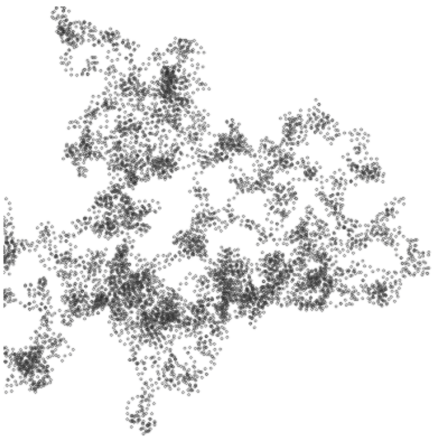
Process: We downloaded some openly available fMRI data from an online source at Carnegie Melon University (http://www.cs.cmu.edu/afs/cs.cmu.edu/project/theo-81/www/), which is in the form of voxels and signal magnitude. With some help, we wrote a javascript function that draws circles in a line. Each new circle is inscribed on the path that is rotated according to the data in the fMRI script.











Design 2 - “Brain” Waves

Motivation: Inspired in part by the “Unfit Bits” project, this design is meant to intervene on an enchanting technology’s mysterious qualities, in this case an Brain-Computer Interface using EEG, and hopefully push the viewer to reconsider what sorts of signals these technologies actually detect. EEG detects fluctuations in electric potentials, and while they are intended to measure these fluctuations from the brain’s neuronal activity, any electronic device would generate them. The intent here is to show that these devices are not directly reading one’s mind, but simply detecting noisy electrical signals and attempting to recognize and classify patterns.

Process: These are images of a Samsung laptop and an Apple iPhone with Emotiv Insight and Mindwave Mobile headsets respectively, edited onto them in Adobe Photoshop. To push this design further and make it more powerful we could in addition carry out this process in reality and record the devices’ EEG data to be displayed as well.

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