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Braindance: A Preliminary Exploration of Technological Knowledge and Neuromarketing

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Abstract: Neuromarketing is the use of imaging technology to ascertain information about brain states during the viewing of advertising and products. It is an area of increasing interest for the purposes of both neuroscience brain research and marketing. At present, there remains significant disagreement about value of knowledge claims made by neuromarketing and its efficacy in both understanding and predicting consumer behavior. This paper outlines an approach to epistemic conception of neuromarketing by applying and broadening the categories of technological knowledge produced by Walter Vincenti and Marc de Vries. Categories of technological knowledge capture several important elements of epistemology and knowledge generation, though more work in areas such as business judgment and knowledge translation remains to be done. The framework provided herein presents new epistemological considerations for the analysis of marketing practice related consumer behavior and brain activity.

Key words: neuromarketing, technological knowledge, epistemology, imaging technology, fMRI

Introduction

The 1990s were hailed as the "Decade of the Brain" (Beaulieu 2001, 635), a new frontier for research and development, primarily in the area of medicine—in the ever-present effort to avert senescence—and as a way of opening a new frontier in understanding the most persistent of human questions: that of our identity. Knowing more about the brain—how we think, why we feel, and other important and fundamental questions about consciousness—seemed to be more accessible

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to answers with researchers availing themselves of new technologies to observe brain activity.

In a short time, those from other disciplines, including marketing, became interested in pursuing an understanding of how the brain reacts to products, to advertising, and to the shopping experience itself. Studies purporting to predict the success of music recording (Berns and Moore 2012), services (Fugate 2008), and the collision between price and value of wine (Plassmann et al. 2008) gave us a window into the brain during buying. They offered an alternative to the inexact and time-consuming methods of market research. Rather than interviewing subjects and observing behaviors and then interpreting opaque and often contradictory indications and reports, one could study brain images and understand how the brain operates when processing information about a product or advertising. Thus was born the field of neuromarketing.

For the sake of brevity and clarity, I have narrowed my definition of neuromarketing to the use of functional magnetic resonance imaging (fMRI) as a technological intermediary to track brain activity while studying psychological/behavioral/physical responses of a customer when they examine products or advertising. Many other imaging technologies can also be used. 'Marketing,' for the purposes of this paper, refers to the practice of creating advertising and designing products and brands which aim to appeal to customers (Kotler 1999). The attachment of the prefix "neuro," signifies a different process of understanding products which appeal to customers, based on a subject's neurological patterns and also the interpretation of those patterns after using an fMRI machine. These images will then be interpreted by an expert trained in interpreting the images and their association with emotions and behaviors; these emotions and behaviors will then be interpreted one more time by a marketing professional in an attempt to discern whether a consumer's response to a product or advertising is the response intended by the creator.

The raison d'etre for practicing neuromarketing is the assumption that a scientifically designed and technologically rendered brain image will elicit more accurate and pertinent information about a potential consumer's response than more prosaic marketing techniques relying on observation and behavioral interpretation, such as interviews, surveys, and focus groups, which are thought to contribute inefficiencies in the area of consumer research due to significant inherent biases of influence, phraseology, misunderstanding (Pradeep 2010; Olteanu 2015; Andrejevic 2012; Choi and Pok 2005). One of the most prominent papers cited to support the link between brain imagery and marketing insight is McClure et al.

2004, which gives evidence that consumers' brain activity shows a linkage and a signature response to a beloved brand (in this instance, Coca-Cola) rather than to a product's actual taste.

This paper takes neuromarketing as a practice, and attempts to understand the types of technological knowledge that are combined into an epistemological whole to create a neuromarketing "event." I argue that the development of neuromarketing knowledge can be explained in part by the frameworks laid out by Marc de Vries (2003) and Walter Vincenti (1990) regarding technological knowledge. Technological knowledge is a form of epistemology, a knowledge that can be accreted through the development, operation, or manipulation of a technological artifact. Knowledge inheres in the creation of a material thing, and thinkers such as Constant (1984), de Vries (2003), Laudan (1984), Vincenti (1990), and Baird (2002) have argued that this epistemology is a unique one.

First, I explore some background of neural imaging and its development as a potential marketing application, delineating some significant critiques regarding its utility. I then summarize the epistemological framework described by historian of engineering Walter Vincenti and expanded by philosopher Marc de Vries and place neuromarketing in that frame. Following that discussion, I offer several conclusions about the implications of the potential framework for neuromarketing and offer some possibilities for future research and analysis.

Buying with Brain Images: Neuromarketing

The functional MRI (fMRI), developed in the 1990s, has a well-established set of expectations and understandings with regard to its use in a clinical medical setting, such as highly detailed renderings of tissue and function. Indeed, fMRI machines produce images that go beyond simple cross-sectional pictures of the body. Instead, software constructs representations of vivid color and sharp resolution using a statistical unit that combines the statistical and physical called the voxel (Beaulieu 2001, 2004). Other scholars have pointed to the expanding constellation of clinical expectations for the fMRI to the inevitable maneuver out of the clinical setting, and even out of the confines of the biological sciences all together (Pillai 2010). While it was once thought of as a breakthrough for studies directly involving brain anatomy, much of the enthusiasm has spread "by a wide variety of researchers in fields as diverse as psychology, neurology, psychology, and linguistics" (Pillai 2010, 219). The use of fMRI, therefore, has expanded beyond what was originally envisioned for it.

Neuromarketing, as a subset of fMRI application, uses many of the same physical cues that might be observed in any other brain imaging setting. In fact, if one were to simply witness such a procedure in the laboratory, it would likely be difficult to discern how the scanning would be different than any other study involving localized brain function. The machines themselves offer several different configurations, some of which may be more agreeable to the subject than others, depending on one's patience, level of tolerance for confined and noisy areas, and other factors. Most studies examining the effectiveness of advertising will include set-ups in which a research subject can view imagery, but brain activity related to several senses may be under study. One notable study found that its subjects preferred the taste of wines they believed to be more expensive—though in reality all the wines they sampled were the same (Plassmann et al. 2008). The touchstone study by McClure et al. (2004) used special tubes for the tasting of chilled Coca-Cola and Pepsi and tilted mirrors such that brands could be observed by the participants within the fMRI device.

The "marketing" aspect of the neuromarketing neologism is possibly the more difficult to define in terms of knowledge, technological or otherwise. The images are interpreted by experts using statistically averaged brain maps or atlases for comparison, resulting in a host of epistemological issues. The images are then re-interpreted by marketers specializing in consumer behavior to gain insight into what could make for actionable marketing practice. As a result of such a study, an advertisement may use a different actor, or a different script. Perhaps the color of the car in an advertisement would change.

Much market research, including that performed by fMRI, is proprietary and often not subject to public or peer review. The degree to which the results of neuromarketing studies have had any impact—positive or negative—is somewhat obscured by the confidentiality of the studies themselves. There is significant economic value for research involving market intelligence and brand perceptions and, with such commercial consequences, it is quite easy to see why this would be the case. Still, even with only a handful of well-known outcomes, even limited practice has found genuine interest.

Controversies of Imagery and Rhetoric

Scholars have examined the scientific merit—and expressed some skepticism toward—the true utility of imaging technology and urge caution toward "overclaims" of knowledge (Satel and Lilienfeld 2013). News headlines tend to occasion the greatest levels of attention generally given to the field, but careful thinkers

with more nuanced approaches have also made some inroads into delimiting the wildest predictions and assessments. Sally Satel and Scott Lilienfeld (2013) explain the problems of extrapolating from imaging technology to human behavior with an example:

> The idea that a specific area in the brain is solely responsible for enabling a given mental function may be intuitively appealing, but in reality it is rarely the case. Mental activities do not map neatly onto discrete brain regions. For example, Broca's area—once believed to be the brain's one and only language-production center—has been discovered not to have exclusive rights over this capacity. More precisely, it can be thought of as one of the key nodes, or convergence centers, for pathways that process language. . . . [M]ost neural real estate is zoned for mixed-use development. (Satel and Lilienfeld 2013, 13)

Joseph Dumit (2004) conducted a thorough study of the social role of brain scans, along with some of the controversies attending their use and practice. He focused on the use of PET (positron emission tomography) scans, which have some significant methodological differences from fMRI, but his analysis is useful for a consideration of brain imaging more generally, and can be applied to practices another step removed from image interpretation such as in neuromarketing.[1] Dumit wrote that "we should become as aware as possible of the *people* who interpret, rephrase, and reframe the facts for us (the *mediators*)" (Dumit 204, 5; emphasis in original).

Dumit's aim was to "follow the images" (2004, 11) and to explore the social exchanges which create interpretations of the images and thereby also create knowledge. Dumit is confident that the scanning of the brain tells us something important about the human mind (2004, 110). This is the underlying hope of many of those who seek to apply the neuroimaging techniques to a new field, and neuromarketing is no exception. But, as in the development as chronicled by Beaulieu and others, the privileging of the visual, the equating of the photograph with objective evidence, can create epistemic concerns.

Dumit also noted the risks pertaining to overconfidence in the use of brain imagery. This corresponds well with what others (Beaulieu 2001, 2004) have stated with regard to the nearly overwhelming sense of import that comes with a visual depiction. The mere idea of being able to *see* something like brain activity creates a presumption of fact, a dominance in the evidentiary realm which overwhelms the reality that an image is interpreted and rendered meaningful by human

intervention. Dumit states that outside of the "careful" original conclusions of scientific articles, brain imagery at large in the broader world—in trials, in newspapers—tends to seek the broadest possible impact, enabling the most sensational claims to move forward (Dumit 2004).

Kelly Joyce (2004) looks further at the phenomenon of MRI and its predominant role in the medical sphere. A sociologist by training, Joyce questions the validity of MRI in certain settings, along with the dominance of the visual axis. Proceeding from a constructivist standpoint, she writes that such images are not a simple representation of how a human body works but that the technology itself "produces" the body according to social forces and expectations (Joyce 2004, 48). The intermediary levels and filters of the imaging technology, in Joyce's estimation, do not produce new knowledge but actually move to distort knowledge of all types, ranging from the practice of medicine to software coding. Joyce emphasized that "artifacts provide a visible symbol of the always occurring interpretation work of medical science, illustrating how *the real can be constructed only through action and practice*" (Joyce 2004, 62, emphasis added). It should be noted that Joyce's approach also appears to elide the existence of an independent physical reality, a stance not unusual among social constructivists. This curtails the explanatory power of the scholarship associated with that approach, however, and Joyce's work is no exception. Critique of imaging technology on almost exclusively social grounds is deceptively simplistic and bypasses the more challenging epistemological questions that can be addressed through other approaches, such as an inquiry based in technological knowledge.

Congruent with Dumit are the broader considerations of Beaulieu (2001, 2004). Beaulieu's work specifically engaged with the issues of the ability, or lack of ability, of neuroimaging equipment to track activity in certain regions of the brain, to correlate that activity with observable behavioral outcomes, and to render that activity in images on which the majority of the fields invested in brain imagery can agree, in terms of probative value, content, and meaning. Beaulieu's work in 2001 focused on the impetus of the 1990s "Decade of the Brain" to connect neuroimaging technologies to useful information (Beaulieu 2001). Expanding on this, in 2004, she wrote that while the "sciences of the mind have . . . taken a biological turn," material developed and uncovered during the research has taken what she termed "an informational turn" (Beaulieu 2004, 368).

Early skepticism of the usage of brain imaging was described by William Uttal, who disputed the utility of brain scanning on the premise that true brain activity is more complex than what the images would yield (Uttal 2002). The

problem, as Uttal stated, wasn't necessarily the idea that certain processes could be mapped onto certain parts of the brain, but that scientific publications favored studies which used imaging to make evidentiary points, to the detriment of other studies which used other (including behavioral) methods (Uttal 2002, 222). This remains an issue still to be resolved even now with regard to imaging and also neuromarketing studies.

More pointedly, Edward Vul and colleagues represent the tip of the spear within the skeptical armamentarium, essentially stating that not only are many fMRI-oriented neuroscientists overconfident in their results, but that virtually all results elicited from such scanning equipment is suspect (Vul et al. 2009). The argument leading to this conclusion characterized what the Vul group believed to be a reliance on interpretations of statistical methods when studying brain images, when in fact those same methods could also bear other interpretations that did not show the same degrees of correlation. At the end of their meta-analysis, they intone: "[W]e are led to conclude that a disturbingly large, and quite prominent, segment of fMRI research on emotion, personality, and social cognition is using seriously defective research methods and producing a profusion of numbers that should be believed" (Vul et al. 2009, 285). Further elaborating the point, authors of another study found viable fMRI results on a dead salmon placed in an imaging suite and shown pictures of human facial expressions (Bennett et al. 2010). The epistemic impact of such conclusions is quite clear: the entire enterprise of brain imaging via fMRI is problematic.

Ensuing and rebutting commentary attempted to demonstrate that, in fact, such methods used in many studies were perfectly sound from an epistemic, statistical, and scientific point of view (see, among others, Lieberman, Berkman, and Wager 2009). The spat caused enough consternation to create ripples in the science journalism world, culminating in a Newsweek piece by Sharon Begley, who captured the dispute in a piece titled "Of Voodoo and the Brain," noting that the public is "obsessed" with brain images (Begley 2009). In contrast, Bechtel (2002) and Raichle (1998) carefully argue that the value of the brain imaging comes in different forms, ranging from better understanding of the ways in which the brain operates to potential ways in which behavior is linked to that activity.

More recent studies, such as that of Mara Mather, John Caccioppo, and Nancy Kanwisher (2013), indicate that fMRI and other brain scans do contain relatively valuable insights pertaining to cognition and the function of the brain. While caution is warranted in interpretations, there are some areas of consensus, including an acknowledgment, at least, of a correlation between brain activity and

some tasks; an agreement that more work needs to be done to improve both the temporal lag of fMRI and voxel resolution; a cautious approach for understanding where processing may actually occur despite the tempting ability to target areas that are visually locatable on an image. In a sense, Mather, Caccioppo, and Kanwisher offer a viewpoint that is more holistic, in the sense that "[t]he best approach to answering questions about cognition therefore is a synergistic combination of behavioral and neuroimaging methods, richly complemented by the wide array of other methods in cognitive neuroscience" (Mather, Caccioppo, and Kanwisher 2013, 113). The more conservative-leaning of the arguments acknowledge methodological, epistemological, and statistical limitations of fMRI studies, including basic problems such as resolution, i.e., how much information does a voxel actually represent?

Images and Emotion: Desire and Buying, Marketing and Neuroscience

The area of greatest interest for neuromarketing and consume research is the emotional response of the consumer while controlling for the risks of reverse inference and general interference. This is particularly clear when considering the complexity of human emotion and many of the associations that companies attempt to form with branding or advertising. Reaction to advertising, the affiliation and affection for a brand, the desire for a product or service are all primarily emotional responses. This focus on emotional response is a departure from the textbook model (envisioning the consumer as a perfectly rational actor, unaffected by emotion or subjective mental state) of how a customer acquires her purchases (Kotler and Keller 2006), but is well understood by anyone who has ever had a desire to make a purchase, or to close a sale.

The affective states of greatest interest to putative neuromarketers are the areas linked to strong emotion: hatred, fear, disgust, excitement, pleasure, joy, loyalty, anger. The ongoing debate between those who propose specific local areas of the brain as being causally linked to these emotional states, and those who propose other models relying on the global nature of brain activity, will likely be heightened by dialogue regarding neuromarketing. However, the only way to continue a discussion on neuromarketing and technological knowledge seems to be to assume that there is some basic level of evidence for the practicality of fMRI brain scans and their marketing interpretation.

Marketing can be best seen as an agglomeration of different techniques, some of which are described in greater detail below. It can be likened to an allied assemblage of skills and tools rather than a strict discipline within the conduct of

operations of a business (or any organization). The strategic goal of *neuro*marketing is such that it is expected to offer up better and greater amounts of knowledge relating to the complex and applied field that is "marketing." The temptation to view a "scientific" technique as objective may prove hard to resist, given that often the idea of what constitutes marketing is fluid and subject to different interpretations. There are several areas where neuromarketing may be sought to play a clarifying role:

- Consumer research (Kotler and Keller 2006): ascertainment of number and type of customers can be enhanced through quality of information offered by neuroimaging of consumer needs and desires.
- Consumer behavior (Kotler and Keller 2006): observational studies and psychological models can be replaced or reinforced by neuroimages
- Branding (Kotler and Keller 2006): The central point of value with many products and companies, as an identity for consumers to rely on and trust, with neuromarketing efforts designed to understand appeal, loyalty, recognition, and price sensitivity. McClure et al. (2004) focused on the strength of the brand of Coca-Cola in terms of their results.
- Price (Kotler and Keller 2006): Long-standing area of behavioral economics and marketing, which represents one of the "Four P's of marketing," and often the most important attribute of a buying decision. Can be better understood by comprehending emotional reactions to price information. Plassmann et al. (2008) focused on price as a trigger of localized brain activity.
- Design (Kotler and Keller 2006): Attractiveness and emotional appeal of an existing or developing product can be gauged by testing consumer response to a design through both behavioral and imaging information.
- Advertising (Kotler and Keller 2006): A central method of marketing communications, imparting information to the consumer. It can include both survey and other behavioral and social research approaches, as well as interpretation of brain activity while viewing advertising.

Marketing combines approaches and tools into an iterative process subject to further judgment and evaluation about the outcomes that are produced. Marketing—be it based in behavior or in neuroscience—is a fundamentally human practice of interpretation and decision.

Ways of Knowing: Technological Knowledge and Neuromarketing

To sum up: a basic imaging process so far: a human research subject is scanned during an interaction with a product or advertisement. This scan is performed by a device on consenting volunteers in order produce interpreted brain images. The mapping that occurs is the result of a combination of factors involving function, locality, brain operations, and the technology itself. The captured images are interpreted by an expert who possesses background and training in linking localized brain activity to behavioral, affective or emotional states or feelings. The interpretation is then linked to conceptions of consumer psychology, with such insights leading to development of a desirable advertisement or product.

Perhaps the prototypical neuromarketing study for the illustration of fMRI and extraction of neuromarketing-relevant conclusions is McClure and colleagues' "Neural Correlates of Behavioral Preference for Culturally Familiar Drinks" (2004). The main finding of the article is that study participants' brain scans showed a strong preference for a *known brand* of cola (McClure et al. 2004, 384). In short, participants' brain scans showed a more excited reaction in areas associated with reward processing when participants knew they were consuming Coca-Cola than when they tasted cola, with brand information hidden from them (McClure et al. 2004). Such a conclusion is extremely attractive to marketers, given the unrelenting focus on brand value in today's marketplace.

To keep things clear, we will move forward using terms and definitions as set out by de Vries (2003) and Vincenti (1990). The latter wrote in terms of specialized engineering design knowledge, but one that captures the unique "what" of the knowledge and the "why" it should be considered as a category unto itself. Vincenti wrote: "I interpret the word *knowledge* broadly. In particular, I take it to include both of what philosopher Gilbert Ryle calls 'knowing how' and 'knowing that,' that is, knowledge of how to perform tasks as well as knowledge of fact" (1990, 13). While Vincenti uses a broad definition of knowledge, he also cautions that his analysis is restricted to knowledge based on the purpose of attaining requirements mandated by the tasks, with the tasks themselves set out by external needs or limitations. Such limitations come from the environment or the market, or by users such as military and commercial partners (1990). Vincenti's work addresses several categories of knowledge: the concept of design and growth of knowledge; requirements and standards; theory and practice; the gathering of data relevant to design; methods of production, and others.

De Vries (2003) seeks to expand general understanding of technology *as* knowledge. De Vries posits that the nature of technological knowledge needs to be further understood in its own domain, separate from the considerations of both scientific epistemology and that of the history of technology. The act of the creation of the artifact itself relies on an epistemological basis distinct from scientific methods. Scientific methodology relies on an epistemological basis which largely stems from observation and experiment, whereas technological knowledge is also embodied in the creation of an artifact. By combining empirical inquiry, problem solving, and a large reliance on "know-how," engineering and technological knowledge and creation relates to, but remains distinguishable from, scientific knowledge (Layton 1971).

De Vries expands and proposes to replace the Vincenti approach using the Local Oxidation of Silicon (LOCOS), a material used in the manufacturing of transistors, as a case study. He attempts to better order Vincenti's approach and the reliance on aeronautical case studies and tuned it to a "smaller" scale by analyzing a particular ingredient used in manufacturing another artifact. The purpose of this downsizing was to observe just how complex of a mix of technological knowledge is required to make even a simple ingredient. His work results in a more thorough and nuanced view of technological knowledge. The four categories of de Vries's knowledge types are physical nature, action, means-end, and functional nature. The categories also exchange energy and overlap with each other.

The development of LOCOS started with an advanced technical understanding of the physical properties of the material itself, or *physical nature knowledge*. Much of the chemistry and physics immersed in the material itself is understood, and taken as a given with the *application* being the area of focus.

Coupled with physical nature knowledge is a different type of knowledge that stems from the recognition of a result necessarily coming about as the consequence of a process. De Vries called this *action knowledge*.

Another category of knowledge is *means-end knowledge*, which describes processes of transformation. It is a distinct class between action and physical nature knowledges which contains a transformative aspect (in the LOCOS case, it was a particular catalyst) that allows action to occur and bridged from physical knowledge. Such means-end knowledge, according to de Vries, is always present and necessary; the implication here is that such knowledge is instrumental in transformation of properties.

De Vries describes a fourth category of knowledge, *functional-nature knowledge*. This category is another form of application, in the sense that function and

knowledge of one type of problem can be applied to a different problem. This category accounts for judgment about the application of previously held knowledge to different types of problems through the establishment of analogical relationships.

The LOCOS case was well-defined, with understood parameters and a fully developed scientific basis for interpreting technological knowledge. There is a defined subject—a particular finish used in a certain application (transistors)—and a confined analysis that is carefully trimmed to suit the patterns of greatest need for that application of the knowledge categories. Can such an analysis be used in an arena where there is no benefit of clear definition and with an unconfined analytical scope to neuromarketing?

In applying these categories of knowledge to neuromarketing, we are confronted with the distinction between Vincenti's observations on aeronautics and de Vries's more limited scope in reviewing of a particular finish on a transistor. Neuromarketing incorporates scientific knowledge and technological development ranging from the cellular scale to equipment that can barely fit in a large room. Another possibility is that neuromarketing, as a combination of disciplines of technoscience ranging from software engineering to radiology to psychology, is an emergent way of knowing that has not been fully captured, and study of the constituent technologies may not bring a full accounting to it. At the very least, if we view the de Vries categories carefully, it appears that technological knowledge changes the nature of scientific knowledge into something else. The categories described and analyzed below in the context of neuromarketing demonstrate these issues for further consideration.

Physical Nature. De Vries describes physical nature as core physical properties which are understood as a matter of fact. The finish that de Vries analyzes in the LOCOS case study applies this straightforwardly: certain atomic and chemical properties and substances are known to carry certain characteristics. It is, at a physical level, consistently described and understood using common terms and through repetitive use of the finish.

In applying the physical nature knowledge to neuromarketing, the task becomes more difficult. Physical nature knowledge consists of the properties of the material or artifact which bears the attributes amenable to interaction with other materials. The fMRI machinery itself is clear. Despite criticism, the software and related engineering for depicting the image of the brain falls within physical nature knowledge, including chemical responses for blood flow within the brain, the ability for hardware to capture that phenomenon, and the ability for the machines to process and display the image. Irrespective of how far one wants to go to the

level of micro-analysis—to that of the cellular or atomic levels to trace the interaction of neurotransmitters and molecular transfer via blood—physical nature knowledge is fundamental to the creation of the entire understanding presented by technological knowledge. Without physical nature knowledge, the remaining categories have little support.

Likewise, as one moves "up" in scope, there is a rough understanding of the physical connections of neural patterns within the brain and a correlation with behavior. It can be said with at least some degree of confidence that the physical nature of the brain is *becoming* better understood. All the properties of any given technology need not be known for that knowledge to fall within the category of physical nature knowledge; the historians of epistemology and philosophers of science admit that knowledge evolves and thinking changes (Kuhn 2012). The category of "knowledge" in this context is as much a process as it is a category encapsulating a genus of understanding.

The physical nature of the "marketing" aspect of neuromarketing may not have its essence in the scanning device at all. The image and, more importantly, the meaning-interpretation of the image is the basis upon which a marketing decision is made. The interpretation is instrumental to the practice of neuromarketing. Simply putting a product designer or advertising producer in a room with a functioning fMRI device will not result in neuromarketing insight. The physical properties in question may not be physical at all, except to the extent that there are artifacts which generate images which are interpreted into a projected future course of action.

Action knowledge. The de Vries approach includes action knowledge, which is the knowledge of a result being elicited from an artifact via a process applied to its physical nature. In the LOCOS case study, there was a smooth continuum between physical nature and action knowledge components. Identifying the process in neuromarketing is a special challenge, given the different possible conceptions of physical nature knowledge and the different processes incorporated in neuromarketing; as noted above, neuromarketing is an interpretive *process*.

In having action knowledge in neuromarketing, an action would need to be elicited from the physical nature of neuromarketing. Exploring the actions associated with the idea of concretize physical nature knowledge could constitute an entire inquiry. These actions could occur in any number of the stages of interpretation and result assessment. There are a number of areas in which a knowledge "distortion" could occur—through physical phenomena, uncertainty about

meaning, image clarity, ambiguity of interpretation, all the way through the social construction critique offered by Joyce and similar (Joyce 2004).

In a successful neuromarketing exercise, one would chart an accurate and validated consumer response derived from a number of different fMRI scans of individuals responding to a product, person, or advertisement. The action knowledge that one might find reflects the usage of the technology imaging the brain patterns, the interpretation of the brain patterns according to known correlations and associations with behaviors and emotions, and the extrapolation from that interpretation of a greater meaning for those attempting to market a product. There are examples, such as McClure et al., which suggest that limited-scope studies with conservative interpretations can result in significant insight with regard to brain activity; such a result might also be subject to other interpretations. Coca-Cola may be enthusiastic about the result, while quite the opposite would be the case for Pepsi. Pepsi might try to discredit the study on epistemic grounds; it may also work very hard to strategize about improving its own brand.

The action knowledge of neuromarketing therefore encompasses several different outcomes. Neuromarketing is predicated on brain imaging and brain science, but it might be that neuromarketing may yield greater insights into studies of human behavior and cognition. One might only realize a true outcome of action knowledge if a better product or advertisement results from neuromarketing, but others might well be present. This, as described by Dan Ariely and Gregory Berns (2010), is the ultimate goal of neuromarketing: that the brain patterns extracted via the imaging technology can be understood in a way that improves an individual consumer's experience of a product or advertisement.

Action knowledge seems to be present throughout the entirety of neuromarketing. Even without the thorough physical nature knowledge that might be present in other example artifacts such as the finish used in LOCOS, the process itself is the major constituent of knowledge. This seems to fit quite well with Vincenti's conception of the formation of engineering knowledge—that it is an iterative process, bounded by external factors, and an outcome of a collective working together to create a solution to a problem (Vincenti 1990). Action knowledge may be an epistemic predecessor to a better and more fundamental physical knowledge. In the de Vries examples, the two were related in terms of action knowledge being produced from physical nature knowledge, but their positions in a neuromarketing context could be considered the reverse of this, at least given the significant gaps in our current knowledge in cognitive science.

Means-end knowledge. This is a category of technical knowledge representing an epistemological transition from physical nature knowledge to action knowledge. A determination of means-end knowledge is means to understand its suitability for a specific purpose. In the LOCOS study, the finish had certain complications in its application and use that required further study and refinement (De Vries 2003). These complications created conditions for a deeper and more fundamental understanding of physical nature; in one sense, the "physical nature" knowledge is enough to open the door, to give an idea, to portray an application. If object "X" carries a certain set of attributes, "A," then it should elicit response "Y." But means-end knowledge occupies a practical and pragmatic space to where one sees that object "X" can get to response "Y" but, in addition to these attributes "A," there are other attributes which create complications in getting to "Y." These attributes, "B" and "C," have to be addressed in terms of their own physical knowledge, as to why it is that they are preventing "X" from leading to "Y."

There are significant deficits in understanding the technoscience of neuromarketing. In essence, the means-end knowledge category defines the weakest areas of neuromarketing in epistemological terms. This deficit is similar to the sense that Satel and Lilienfeld (2013) recounted in their description of the recursive complexity of the brain, and the lack of a one-to-one correlation from one part of the brain to a certain type or even set of behaviors. This is also in contrast to what de Vries discovered with well-defined LOCOS case study: the degree of ambiguity that flowed back and forth in categories of knowledge in an iterative form.

The lack of certainty with regard to means and ends, and the incorporation of an iterative process, are still indicative of epistemological value. Marketplace competition, product development, and capturing consumer attention are all important parts of a functioning business (Kotler and Keller 2006). Most companies expect products to have a set period of viability in the marketplace. In a sense, the entire process of marketing and business itself is iterative, particularly in a competitive marketplace. Most product introductions will fail; the exception is the product that can remain viable, or even at the pinnacle of the marketplace, unmolested, for more than a few years (Kotler and Keller 2006). This means that ends, might always be subject to change. Whether the means required to attain those changing ends must change as well is a separate question, but certainly not a strange one.

Functional nature knowledge. The question of functional nature knowledge is one of knowledge intention. That is, the artifact possesses properties that can be described as consistent with the underlying intention of its use. As recounted

above, the development of imaging, and specifically the fMRI technology, is a story of applications and interpretations added over time; this also means that there are multiple intentions behind its use. Research led to diagnostic and evaluative medicine, which led to psychological insights, which led to further understanding of potential changes in the organic structure of the brain, which led back to further psychological research. The latest iteration, which we see in neuromarketing, extends a finding and interpretation from behavioral research and uses that interpretation to create a stimulus that reliably results in that behavior.

In neuromarketing, significant overlap exists in this category of knowledge. We have visited several occasions above where neuromarketing as one potential application of technoscience can lead to fresh conclusions in the various constituent fields of behavioral and neuroscientific research. Cognitive and behavioral research and technical refinement can all be considered transferable and functional nature knowledge. There is another layer to functional nature knowledge, however, which would be a new category of understanding that neuromarketing truly is seeking: if one can build better products based on brain patterns and understanding the "true" consumer brain, then might this lead to changing the consumer's perception or even her decision-making? It seems that functional knowledge in this context might make a fundamental change in techniques of persuading customers.

This category, therefore, is likely to be the one of the four which has the potential to be the most transformative and is likely also the least understood. It also is the category of technological knowledge that slides around most easily on the spectrum of events in the process of neuromarketing: imaging, interpretation, reification. The properties of a brain image relevant to marketing do not become neuromarketing until they are interpreted into relevance for marketing.

Observations about Technical Knowledge and the de Vries Categories

The de Vries categories fit the LOCOS work well and do a creditable job of explaining the acquisition of technological knowledge. Neuromarketing does not yet have the clear definition of LOCOS, for a variety of reasons. Indeed, the LOCOS interpretation and the de Vries categories seem to share much in common with the epistemic thread that argues in favor of technology as applied science, an argument that Vincenti and others dispute. The characterization of the starting point of knowledge is therefore highly important in considering the degree to which there is an epistemological understanding, let alone one that can be best understood using technological knowledge.

There is a legitimate question, given an epistemological analysis such as the one in this paper, as to what neuromarketing actually is in an epistemic sense. This is seen clearly in the difficulty of assigning de Vries categories to neuromarketing practice. As described, the neuromarketing process consists of layers of discrete steps which have been combined in an effort to add to the toolbox of marketing professionals: the imaging, the interpretation, and the re-interpretation. Separate epistemic concerns exist along each step, some technological knowledge in nature, others scientific. There is a deep connection between the two. In neuromarketing, knowledge generation begins to occur when *meaning is ascribed to certain areas of brain activity*. This results in a clearer epistemic description when considered in marketing terms, such as branding, consumer attributes, and product design. Following the elicitation of meaning from the images, already influenced and positioned by virtue of being placed into action by marketing intent, the data and knowledge are interpreted solely through terms of marketing, providing insight into branding, a target market, or the appearance of a product.

But what if, for some reason, a neuromarketing project is terminated before its knowledge appears in a new product? Did neuromarketing then even occur, if the effort expended had little to show for the expense? Those performing a neuromarketing study would presumably retain knowledge and insight—even knowledge that could lead to erroneous action—from a neuromarketing study, even if the study itself had no relationship to a decision regarding an advertisement or a product. Such knowledge could conceivably contribute to some other domain—perhaps as a future product, or simply as an addition to the growing corpus of brain research.

Supposing, however, that neuromarketing on the average does offer methods for improving products and advertising, an epistemic understanding of the practice cannot be reached by applying de Vries and Vincenti separately, given the gaps in knowledge still unaccounted for by either of the theories. In combination, however, their definitions of technological knowledge could present a more coherent picture. Neuromarketing itself is a combination of many constituents, including, among others, software engineering, medicine, neurology, cognitive science, psychology, and business management. One can discern three distinct stages: the capture of an image, its interpretation in terms of brain activity and affective state, and the reification of the interpreted brain activity/affective state into marketing insight, which also might include questions of judgment and finance.

Vincenti's approach, while less specific than that of de Vries, seems better able to accommodate a consideration of neuromarketing as technological

knowledge. In all of Vincenti's categories, the actors managed a broad spectrum of uncertainties pertaining to the problem on which they were focused, whether smoothing rivets in a fuselage or designing an aircraft wing. Vincenti stated his interest in technology as knowledge and the formation of social groups which created the artifacts embodying that knowledge at the outset of his study (1990). It is necessary to note the ways in which different social groups reflect on neuromarketing as practice and technology.

The categories described by de Vries are critical to creating a better understanding about the constituents of a technology and the knowledge contained within an artifact. In an effort to clarify some other areas a within Vincenti's work and some other considerations of technological knowledge, however, the categories seem to map out an area of technological knowledge that is unexplained and perhaps unexplainable: the role of chance, guesses, mistakes, inexactitude in knowledge production. These are, critically, the components that formulate the bulk of the controversy within neuromarketing. In addition, the idea of independent "judgment" seems to require an accounting when considering certain technologies. This is a point made by Vincenti.

Vincenti, while taking pains to describe his work as that of engineering rather than encompassing all technology, describes a social process of estimation and innovation that deals with unknown fields. It is, for example, difficult to categorize a form of technological knowledge as physical nature if that nature itself has not yet been defined. Vincenti's work in describing the experience of the user and the communications between users of a technology and their designer is more readily analogous to the process transpiring within neuromarketing (Vincenti 1990).

De Vries set out to establish categories which would replace the Vincenti conception of technological knowledge. That may be a step forward in areas of clear definition and well-understood, non-controversial developments and innovations. It may be limited, however, to a well-understood and well-documented historical invention. An emerging, unfolding phenomenon, where the bulk of underlying principles may yet lie undiscovered, requires a conception of technological knowledge that allows for blurred boundaries and indeterminate truths.

Conclusions

Several things immediately stand out. The categories of knowing enumerated by theorists of technological knowledge are, in the context of neuromarketing, combined in a way that makes it an evolving way of knowing things about itself and about the subjects it studies. The degree to which neuromarketing is so different

that it represents an entirely different type of technological knowledge remains to be seen, but it might also illustrate that technological knowledge is more of a continuum or a process than a concrete list of discrete categories. It would follow that the newer a technology or the more emergent the field it represents, the categories are less fixed. It therefore exudes qualities more akin to that of an unfolding process. A future direction of research could be a comparison and analysis of such a phenomenon.

Many questions remain unanswered, not only in terms of the epistemology of technoscience but about the nature of neuromarketing itself: What makes neuromarketing more objective than self-reported (and self-deceptive) consumer behavior? To bring this back around to the fundamental categories of technological knowledge: why is the epistemology of neuromarketing qualitatively better than the reported phenomenological experience of the consumer? Questions relying on behaviors and self-reported behaviors have their own epistemic consequences which are often well-known, well-understood, and controllable.

Neuromarketing's quest for the "truth" might be distorted by the interpretations *already occurring* within the subject's brain when confronted by an image. In other words, there is more mediation and intermediation than what is already accounted for within the machines and programs and radiologists and psychologists and marketers themselves. Collisions of different scientific and technological epistemologies therefore abound and should be given further consideration.

Perhaps we should think of another approach to these questions: that neuromarketing is not really a "technology" at all, at least in the sense in which a program of technological knowledge could assist in understanding. It seems to have partial fits within the de Vries categories of knowledge, and is rather nebulous even within the broader confines of that described by Vincenti. The mere inclusion of a technological implement such as an fMRI device does not make neuromarketing a technology unto itself, embodying technological knowledge. The printed book is almost certainly a form of technology, but the genre and subject matter printed within a specific volume do not have to be. An instruction manual for building a bridge is an easy case to make for words carrying technological knowledge; perhaps the answer is less so for a novel classified as a "technothriller."

Epistemological categorization based on the de Vries model can be used to analyze complex technoscientific artifacts and practices associated with those artifacts, so long as they are clearly defined and surrounded by clear boundaries. Such an analysis will yield insight into technological ways of knowing and also, when raised to a more macro-level, it shows an emergence of a different direction of knowing that

is encapsulated within the technology or its method. The adaptation of this model to other areas of multidisciplinary technological case studies should bear similar fruit.

We may continue to debate the probity of neuromarketing in application, as we may continue to debate the probity of neuroimages more generally. But in the meantime, we should consider de Vries, Vincenti, and others as all contributing valuable insights when uncertainty reigns, as it currently does in this area of technoscience. Open-ended and broad questions remain, and the epistemological approaches which allow for uncertainties are the approaches which will yield the greatest insights. It will help to understand how we know what we know.

Neuromarketing is currently in an early stage of development, and one's attempts to get in "on the ground floor" in examining knowledge formation may prove to be of great value, so long as those efforts cast the net in a broad manner, capturing all the knowledge and all of its ambiguity.

Notes

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1. Imaging technology already includes interpretation by the designers of the artifact, the software used in the artifact, and those studying the images. The added step within neuromarketing is in extracting an actionable marketing meaning from interpretation of images.

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