Chapter 2
Neuromarketing: Understanding the Application of Neuroscientific Methods Within Marketing Research

Terry Daugherty and Ernest Hoffman

2.1 Introduction

A growing interest within marketing research is the movement away from self-reported consumer research toward the use of direct neuroscientific methods—characterized as *neuromarketing* (see Fig. 2.1). Neuromarketing is the application of neuroscience measurement techniques for understanding how consumers respond, both consciously and unconsciously, to marketing (Lee et al. 2007). This emerging discipline lies at the intersection of consumer behavior, neuroscience, economics, and psychology (Garcia and Saad 2008; Gordon 2002; Morin 2011) while examining a range of marketing topics, such as persuasion, decision making, cognition, and ethics, among others. The potential of neuromarketing has seemingly been embraced by many scholars (e.g., Advertising Research Foundation NeuroStandards Project 2013) and industry leaders (e.g., Nielsen, Buyology, Gallup and Robinson, Innerscope Research), and is often attributed to (a) an appreciation for scientific and objective measurement, which is preferable to more subjective methodological paradigms (e.g., surveys, focus groups), and (b) claims that such techniques constitute more accessible and cost-effective means (Ariely and Berns 2010; Daugherty, Hoffman and Kennedy 2016; Pradeep 2010). Nonetheless, in this chapter we contend that the full potential of neuromarketing has yet to be reached and present a baseline context for understanding common neuroscientific techniques within marketing research.

T. Daugherty (✉)
Department of Marketing, College of Business Administration, University of Akron, Akron, OH, USA
e-mail: terry.daugherty@uakron.edu

E. Hoffman
PRADCO, Columbus, OH, USA

A.R. Thomas et al. (eds.), *Ethics and Neuromarketing*,
DOI 10.1007/978-3-319-45609-6_2

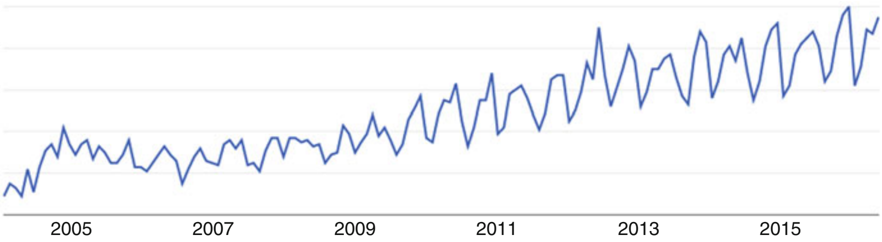

Fig. 2.1 Interest over time in neuromarketing. *Source*: Google Trends

2.2 Understanding Neuromarketing

Fundamentally, neuromarketing seeks to apply the principles, methodologies, and research findings of neuroscience to further understand and explore underlying neurological and physiological correlates of key human behaviors (Hubert 2010). This means that marketers engaged in this type of research must have a basic understanding of the human brain and nervous system in order to hypothesize about neurological reactions to marketing stimuli (Donavan et al. 2016). As a research discipline, neuromarketing is currently in a stage of infancy, continuing to define and develop its theoretical, empirical, and practical latitude (Garcia and Saad 2008; Lee et al. 2007). Growth in the area has been coupled with conflict as many have sought to distinguish between the practical utility of neuroscientific techniques as effective measurement tools and the academic utility such techniques potentially offer in terms of advancing existing theory and findings pertaining to marketing research (e.g., Fisher et al. 2010). Toward this end, Hubert and Kenning (2008) aptly discriminate between neuromarketing as the practical application of neuroscientific technology, and consumer neuroscience as the application of neuroscience to the scientific study of consumer behavior (see also Hubert 2010). While a debate may play out among marketing scholars, the concepts are often used interchangeably, which is our interpretation for this chapter.

2.3 Neuroscience Measurement

2.3.1 Psychophysical

Marketing researchers have relied upon indirect physiological measures of neurological processes long before the advent of neuromarketing as we know it today. Commonly referred to as psychophysical measurements (Camerer et al. 2005; Kenning and Linzmajer 2011), these techniques assess physical responses emanating from non-brain parts of the body to infer the existence of increased or decreased neurological function, most typically with regard to arousal. Numerous psychophysical procedures have been utilized in marketing research and each has been met with a different degree of success and scrutiny. Among the first to be used were pupillary response measures, which reflect changes in pupil size and are consistent with arousal and more specifically with pleasure (Hess and Polt 1960; Hess 1965). Significant differences in pupil size appear to correlate well with advertising effectiveness (e.g., Krugman 1965; Van Bortel 1968; Hess 1968; Stafford et al. 1970) but critics are quick to point out that pupil size can vary as a function of numerous processes (Watson and Gatchel 1979). Marketing research has also analyzed general eye movement and fixation as indicative of voluntary attention (e.g., Bogart and Tolley 1988; Lohse 1997; Wedel and Pieters 2000; Pieters and Wedel 2004) although some (e.g., Kroeber-Riel 1979; Pieters et al. 1999) remain skeptical about the inferences that can be drawn from a presence of lack of eye fixation.

In turn, galvanic skin response (GSR) measures the amount of resistance or conductance human skin exhibits in response to electrical current on the basis of the idea that increased resistance due to sweat gland activation is indicative of arousal. Marketing stimuli have primarily been assessed for “warmth” or likability using GSR (e.g., Aaker et al. 1986; LaBarbera and Tucciarone 1995; Stayman and Aaker 1993). However, its validity for measuring warmth has been questioned, most notably by Van den Abeele and Maclachlan (1994), who managed to demonstrate that GSR and an alternative measure of warmth, though correlated, gauged different affective responses. Voice pitch analysis has also been used to examine fluctuations of pitch as an indicator of affective (i.e., arousal-based) change. Despite its ability to discriminate well between effective and ineffective approaches to advertising (Brickman 1976, 1980; Nelson and Schwartz 1979; see also Wang and Minor 2008), the construct validity (i.e., ability to measure arousal) of voice pitch analysis was convincingly challenged (Nighswonger and Martin 1981) and subsequent use of the technique was abandoned. However, Wang and Minor (2008) suggest that technological advances in voice-capturing software could reestablish the method’s viability. Additional psychophysical measurements that have been used in marketing research include heart rate response (e.g., Bolls et al. 2001, 2003; Lang et al. 2002; Smith and Dickhaut 2005; Watson and Gatchel 1979), vascular activity (e.g., Frost and Stauffer 1987; Sanbonmatsu and Kardes 1988), blood pressure (Camerer et al. 2005), and facial muscle activity (e.g., Bolls et al. 2001; Cacioppo and Petty 1983; Hazlett and Hazlett 1999; Potter et al. 2006). Although variations of these techniques continue to be used by some in marketing research, the prospect of directly measuring neurological processes by means of neuroimaging equipment has proven appealing to a quickly growing number of researchers and practitioners.

Direct neuroimaging techniques are typically subsumed under two broad categories distinguishable both in terms of what they measure and the type of information they provide (Kenning et al. 2007; Plassmann et al. 2007a, b, c), which are focused on measuring electrical and metabolic brain activity.

2.3.2 Electrical Brain Activity

The first broad category of imaging methods measures the specific nature of electrical activity occurring in the brain. A distinct advantage of analyzing electrical brain activity is its temporal resolution, specifically its ability to monitor and detect change in neurological function occurring within a matter of milliseconds (Perrachione and Perrachione 2008; Reimann et al. 2011). In contrast, a notable criticism for measures of electrical brain activity is that there is limited (at least in their current form) spatial resolution, or localization of electrical conduction to specific regions or structures of the brain (Kenning et al. 2007). It should be noted that this has been debated extensively by neuroscience scholars. Specifically, some contend that statistical techniques and algorithms can be used to sufficiently isolate sources of electrical activity, a technique referred to as *source localization* (e.g., Koles 1998; Koles et al. 1995). Cook et al. (2011) very recently suggested that source localization can be useful in the context of marketing. Using EEG technology with source localization, Cook and colleagues were able to show that logical persuasive ads elicited consistently higher activity specific to the orbitofrontal, anterior cingulate, amygdala, and hippocampal regions when compared to messages not requiring conscious recognition. For the most part, two related techniques for measuring electrical brain activity have been utilized and scrutinized within the consumer neuroscience literature: electroencephalography (EEG) and magnetoencephalography (MEG).

EEG measures changes in electrical fields of the brain by reading electrical signals as they register with varying degrees of frequency and amplitude across a series of electrodes applied to the scalp (Ariely and Berns 2010). In response to stimuli, the neural axons of billions of neurons produce electrical activity ("evoked potentials") as information is transmitted across neuronal connections. The electrical current produced by this activity possesses a number of frequency patterns, which are frequently referred to as brainwaves (Morin 2011). Previous theory and findings have linked different brainwave frequencies to various neurological processes, enabling researchers to target and measure specific responses to targeted stimuli. For instance, arousal was measured in early research as the relative degree of beta wave frequency (e.g., >12 Hz) to alpha wave frequency (e.g., 8–12 Hz) production (Weinstein et al. 1984). Modern approaches have relied upon the frequency of brain waves occurring around specific points in time, including the N270 and P300 waves (e.g., Ma et al. 2007, 2008, 2010). Among the challenges of effectively using EEG are distinguishing between true evoked potentials and "noise" produced by other electrical signals transmitted by environmental (e.g., computers) and human (e.g., blinking) sources (Kenning and Linzmajer 2011). Along these lines, Vecchiato et al. (2010) express legitimate concern that type 1 errors (e.g., concluding that targeted stimuli produce significant differences in brain activation when in fact they do not) are a frequent occurrence in EEG research due to misinterpreted data, although they suggest that this can be remedied via the use of appropriate statistical correction procedures.

MEG measures changes in magnetic fields occurring as electrical brain activity fluctuates (Ariely and Berns 2010; Kenning and Linzmajer 2011; Kenning and Plassman 2005). Less distortion by the skull makes it possible for MEG to provide superior spatial resolution compared to EEG. Furthermore, the sensitivity of MEG magnets makes it possible to depict the activity of deeper brain structures (Kenning and Linzmajer 2011), although some have expressed skepticism with regard to its measurement accuracy at subcortical levels (e.g., Morin 2011). The cost of employing MEG technology currently far exceeds the cost of EEG and the increased spatial resolution it provides remains inferior to other neuroimaging technologies (Perrachione and Perrachione 2008). Additionally, MEG techniques inherit all the challenges intrinsic to electrical brainwave research, most notably "noise"-producing data unrelated to subject brain activity (Kenning and Linzmajer 2011) and the subsequent potential of committing type 1 errors (Vecchiato et al. 2010c).

Alternative approaches to directly measuring electrical fluctuation in the brain are beginning to emerge but have yet to gain significant momentum within the realm of marketing. Nevertheless, these techniques merit mentioning inasmuch as their future application to marketing research has been recommended and explored. Transcranial magnetic stimulation (TMS) creates a magnetic field capable of administering non-harmful electrical currents to specific regions of neurons, enabling researchers to temporarily disrupt functioning in targeted areas of the brain (Ariely and Berns 2010; Camerer et al. 2005; Kenning and Linzmajer 2011). Researchers using TMS can explore the causal role of brain activation as they are able to experimentally manipulate the existence or the absence of a regional or structural contribution. Like EEG and MEG, the effectiveness of TMS currently remains somewhat limited to (cortical) areas just beneath the scalp. It is also a challenge to isolate the effects of TMS currents to targeted areas, and concerns persist about the potential for adverse effects including seizures and neural tissue damage (Camerer et al. 2005; Kenning and Linzmajer 2011). Brain lesion studies also offer the potential to yield causal inferences pertaining to advertising stimuli (Camerer et al. 2005). For instance, Koenigs and Tranel (2008) demonstrate the promise of marketing research conducted among subjects with documented brain lesions. Replicating earlier findings by McClure et al. (2004), the researchers found that participants with preexisting damage to the ventromedial prefrontal cortex (VMPFC) did not demonstrate a preference bias, while participants with no brain damage showed a clear preference based on brand-related imagery.

2.3.3 Metabolic Brain Activity

A second broad category of imaging methods measures metabolic or energy-consuming processes occurring in the brain (Kenning et al. 2007; Plassmann et al. 2007a, b, c). Despite possessing relatively poor temporal resolution, metabolic analyses afford a high degree of spatial resolution (Kenning et al. 2007; Reimann et al. 2011), enabling researchers to identify activation in specific brain regions or structures, typically within millimeters of its source (Perrachione and Perrachione 2008). Metabolic measurements can either provide a static, momentary snapshot of neural activation or a dynamic view whereby complex neurological processes can be observed as they unfold. The two techniques receiving the most attention in consumer neuroscience literature are functional magnetic resonance imaging (fMRI) and positron emission tomography (PET).

fMRI relies upon the different magnetic properties of oxygenated and deoxygenated blood to measure the strength of a signal known as the blood-oxygen-level-dependent (i.e., BOLD) signal (Kenning and Linzmajer 2011). Oxygenated blood is consistent with brain metabolism, which occurs as different regions and structures of the brain are activated in response to various stimuli. Reimann and colleagues (2011) suggests that four unique features of fMRI make it particularly useful in research pertaining to consumer behavior: the ability to measure processing as it occurs, the measurement of nonconscious processes that are often missed by traditional self-report methods, differentiation (and localization) of phenomena that research participants struggle to distinguish, and ability to measure competing processes occurring simultaneously. Furthermore, fMRI can and has been used to validate existing measures of marketing effectiveness (Dietvorst et al. 2009).

For all of its benefits, fMRI technology is not without its limitations. Access to fMRI technology is somewhat limited due to its expense and the training researchers need to have in order to utilize it appropriately. Related to this issue, Reimann et al. (2011) voiced concern about a frequent tendency to misinterpret fMRI data so as to wrongly infer brain function from brain activation. For instance, data showing increased activation in the amygdala does not provide a sufficient basis for concluding that participants experienced fear, since the amygdala is also believed to be a neurological center for learning. A number of neuromarketing research firms are utilizing fMRI (Fisher et al. 2010) although the nature and quality of the data they collect and the conclusions they draw from such data remain unexplored. Nevertheless, the ability to observe differential activation of key brain structures affords a seemingly limitless range of research opportunities, leading some (e.g., Morin 2011) to predict that fMRI will eventually become the technique of choice for neuromarketing.

PET measures the gamma radiation produced when radioactive molecules (e.g., fluorine) administered prior to the scan decay in response to gluco-metabolism in the brain (Plassmann et al. 2007a, b, c). A point of origin for the decaying molecules can be estimated within millimeters (Perrachione and Perrachione 2008), providing researchers with a fine-detail spatial estimate of metabolic processes. A major disadvantage of PET technology is its invasive nature. Specifically, because it relies upon the use of radioactive tracers, its use with healthy subjects is generally discouraged (Kenning and Linzmajer 2011; Kenning et al. 2007; Shamoo 2010). Temporal resolution is also limited, and PET equipment can be very expensive. Notwithstanding these limitations, reviews of neuromarketing continue to highlight PET's capabilities while suggesting its potential benefits.

A number of additional techniques can be utilized to provide static images of brain structure. In theory, such images could be qualitatively or quantitatively compared over time, as they often are in traditional medical contexts, to arrive at important insights about brain functioning (Draganski et al. 2004). Perrachione and Perrachione (2008) compare and contrast these techniques, which include magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI). Neuromarketers and consumer neuroscientists are typically not concerned with static and structural imaging technologies due to the existence and relative accessibility of more sophisticated techniques. When possible, it is preferable to observe dynamic changes in electrical activity and metabolic functioning as it evolves in response to targeted stimuli (e.g., advertisements) as opposed to general structural differences. Nevertheless, it remains a possibility that future research questions in the realm of applied science could be further explored with the assistance of these devices.

2.3.4 Multi-Model Measures

Some suggest that perhaps the greatest benefit can be derived from combining the use of multiple technologies (e.g., Kenning and Linzmajer 2011). For instance, the combined use of EEG and fMRI would enable researchers to identify specific brain structure activation corresponding to the production of electrical brain activity. Increased depth and breadth of data would allow for more detailed analyses while potentially allowing one to distinguish the true effect of marketing stimuli from random noise. The field of neuroscience has attempted to synthesize techniques with impressive results (e.g., Debener et al. 2006). Although it is clearly more expensive and analytically complex to combine techniques, we anticipate that neuromarketing research paradigms will increasingly reflect integration in the future, especially involving a combination of psychophysical and brain activity.

2.4 Neuromarketing Taxonomy

In contrast to the wide array of potential research avenues previously discussed, early work in what we characterize today as neuromarketing has generally addressed a limited number of discernible areas. However, previous attempts to organize these findings taxonomically have yielded inconsistent results. Fugate (2007) subdivides existing neuromarketing research into five broad areas exhibiting clear application to marketing: testing advertising effectiveness (e.g., Harris 2006; Herman 2007; Schafer 2005), testing product appeal (e.g., Britt 2004; Singer 2004), celebrity endorsements (e.g., Mucha 2005), logo/brand selection (e.g., Herman 2005; McClure et al. 2004; Singer 2004; Yoon et al. 2006), and media selection (e.g., Reynolds 2006; Walton 2004). Although intuitively appealing, Fugate's (2007) taxonomy is largely derived from nonempirical sources. Meanwhile, Hubert and Kenning (2008) exclusively focus on peer-reviewed academic literature, which they divide into five different groupings: product policy (e.g., Erk et al. 2002), price policy (e.g., Knutson et al. 2007; Plassmann et al.

2007a, b, c), communication policy (e.g., Ambler et al. 2000; Kenning et al. 2007; Rossiter and Silberstein 2001), distribution policy (e.g., Deppe et al. 2005a, 2007; Plassmann et al. 2007a, b, c), and brand research (e.g., Deppe et al. 2005b; Koenigs and Tranel 2008; McClure et al. 2004; Schaefer et al. 2006; Yoon et al. 2006).

Research completed since Hubert and Kenning (2008) propose that their taxonomy makes it worthwhile to revisit and recategorize extant neuromarketing research. New areas of interest have recently emerged relying on neuroscientific measures, including product appraisal (e.g., Cheung et al. 2010; Schaefer and Rotte 2010; Vecchiato et al. 2010a, b, c), purchase behavior (e.g., Grosenick et al. 2008; Reimann et al. 2010; Stallen et al. 2010), and brand extension (e.g., Ma et al. 2007, 2008, 2010). While neuromarketing is capable of including a wide range of identifiable topics, the need to organize studies for the dual purpose of assessing the current state of the literature and generating novel insights could serve future researchers well. Therefore, we propose a reorganized and updated taxonomy that includes six distinct categories for framing existing research in terms of desired marketing outcomes: consumer attention/arousal, product/brand appraisal, product/brand preference, purchase behavior, memory, and brand extension. While a complete and exhaustive list of all published research within each category is beyond the scope of this chapter, Table 2.1 provides definitions and identifies relevant literature for each of these areas with the following sections presenting brief general overviews and supporting examples.

To begin, a significant strand of neuromarketing research is dedicated to exploring features of marketing stimuli (e.g., product packaging, use of imagery) that capture an optimal amount of consumer attention and arousal. Although terms like attention and arousal are often considered interchangeably, they connote different things. *Attention* refers to cognitive awareness of environmental stimuli while *arousal* denotes an immediate and basic emotional response. In spite of this difference, both attention and arousal signify heightened awareness of, and attention to, external stimuli, and so we consider them separately below but group them together within our taxonomy as an outcome of interest to marketing researchers.

2.4.1 Consumer Attention

Attracting attention toward any form of marketing is perhaps the most basic goal. One such means for assessing attention to the features of marketing stimuli has involved the use of eye movement tracking software and hardware. Fixation target and frequency (i.e., length of time focused on a target, number of fixation targets) can be assessed this way, yielding valuable information in regard to the salient characteristics of stimuli. Most work in this area relies on the use of eye movement tracking systems designed to measure the emotional antecedents (e.g., the element of surprise) and the persuasive consequences of stimuli eliciting a high

Table 2.1 An updated taxonomy of neuromarketing literature

Category	Research focus	Relevant literature
Attention/ arousal	Features stimuli eliciting attention and emotional arousal	Bolls et al. (2001), Daugherty and Hoffman (2014), Gakhal and Senior (2008), Groeppel-Klein (2005), Groeppel-Klein and Baun (2001), Groeppel-Klein et al. (2005), Hoffman and Daugherty (2013), Kroeber-Riel (1984), Krugman et al. (1994), Morris et al. (2009), Ohme et al. (2009, 2010a, b, 2011), Rothschild et al. (1986), and Treleaven-Hassard et al. (2010)
Product/ brand appraisal	Neurological correlates of various marketing-based judgments	Cheung et al. (2010), Daugherty et al. (2016), Deppe et al. (2005a, b), Erk et al. (2002), Kato et al. (2009), Krugman (1971), Ohme et al. (2010a, b), Riedl et al. (2010), Rothschild et al. (1988), Schaefer and Rotte (2007a, b, 2010), Stoll et al. (2008), Telpaz et al. (2015), Vecchiato et al. (2010b, 2011), Yoon et al. (2006), and Yu-Ping et al. (2015)
Product/ brand preference	Differences between preferred and non-preferred brands	Ambler et al. (2004), Boksem and Smidts (2015), Braeutigam et al. (2001), Braeutigam et al. (2004), Coates et al. (2004), Koenigs and Tranel (2008), Knutson et al. (2007), Lin et al. (2010), Marques dos Santos et al. (2016), McClure et al. (2004), Paulus and Frank (2003), Pieters and Warlop (1999), Plassmann et al. (2007a, b, c, 2008), and Reimann et al. (2010, 2012a, b)
Purchase behavior	External and internal influences on consumer behavioral and intentions	Kuhnen and Knutson (2005), Plassmann et al. (2007a, b, c), Reimann et al. (2011), and Stallen et al. (2010)
Memory	Factors contributing to future recall and recognition of marketing stimuli	Ambler et al. (2000), Astolfi et al. (2008), Fallani et al. (2008), Hazlett and Hazlett (1999), Klucharev et al. (2008), Langleben et al. (2009), Rossiter and Silberstein (2001), Rossiter et al. (2001), Rothschild and Hyun (1990), Rothschild et al. (1986), and Vecchiato et al. (2010c)
Brand extension	Neural indicators of successful and non-successful brand extensions	Ma et al. (2007, 2008, 2010) and Stewart et al. (2004)

degree of fixation frequency. However, EEG technology has also been utilized to better understand the dynamics of attention associated with marketing features. For instance, Rothschild et al. (1986) showed participants 18 commercials embedded within an hour of television programming while recording electrical brain activity with EEG. Commercials associated with higher levels of learning produced decreased alpha wave production, a phenomenon believed to be consistent with higher levels of attention. More recently, an EEG study conducted by Treleaven-Hassard et al. (2010) measured attention in terms of the incidence of one particular brain wave, the P3a wave, as participants engaged with interactive and noninteractive forms of television ads. While P3a latency decreased over time in response to brands that were presented in an interactive way, it remained the same for brands portrayed in noninteractive ways, indicating that attention was greater for interactive ad presentation.

2.4.2 Consumer Arousal

In turn, arousal has also been measured in a number of studies as a means of gauging emotional responses to marketing techniques. For example, seeking to establish the superiority of physiological indicators of arousal to more traditional self-report measures, Groeppel-Klein (2005) conducted a series of studies where participants were free to move around a store or a series of stores (i.e., the first floor of a mall). Results indicated that electrodermal measurements, unlike self-reports, were more sensitive to change and were also more accurate in the sense that they could be measured in sync with the perception of targeted stimuli (as opposed to later on). In addition, GSR was used by Gakhal and Senior (2008) to investigate whether the use of attractive and/or famous models served to add additional emotional selling property (ESP) to promoted products. Surprisingly, the authors concluded that "average-looking" (i.e., as opposed to "attractive") celebrities produced more arousal than any other condition, suggesting that fame does more to drive emotional response than physical beauty. In another example, Bolls et al. (2001) combined facial electromyography (EMG) with other physiological indicators of arousal (heart rate and skin conductance) to measure radio listener's emotional responses to advertisements determined to be positive or negative in tone. Ads with a negative valence were found to elicit more arousal than their positive counterparts.

One of the more compelling claims of neuromarketing research is that neuroimaging techniques can be used to identify critical emotional aspects of ads that elude conscious recognition. Ohme et al. (2009) coupled 16-node EEG with facial electromyography (EMG) and skin conductance analysis to assess arousal reactions to an altered scene in a commercial advertisement. Significant differences in arousal were detected by all of these techniques, despite the fact that the altered feature of the ad was not consciously seen. In a related study, Ohme et al. (2010a, b) demonstrated subconscious aspects of ad awareness, using EEG to reveal that an unintended aspect of a Sony Bravia tv ad (e.g., a frog that unintentionally appeared in a frame of the commercial as it was being produced) elicited an unexpected and strong emotional response on the part of consumers to the ad itself. The authors conclude that neuroimaging technologies can provide significant insight to marketing producers as they seek to understand the unintended (and intended) consequences of various ad elements.

In summary, neuromarketing researchers have utilized various techniques, both indirect and direct, to evaluate the neurological correlates of attention and arousal. Though slightly different, attention and arousal share a similar appeal to marketing practitioners, who first and foremost seek to make consumers aware that a particular product or brand exists. Research in this area may benefit from exploring contextual variables that act to either facilitate or inhibit attention/arousal. For example, different modes of media presentation (e.g., print, radio, television, Internet) may rely upon distinct combinations of neurological processes (e.g., affective, cognitive) to increase or decrease arousal/awareness. Comparing and contrasting neural reactions (e.g., brainwave activity, brain functionality) to diverse media types could also provide tremendous insight to advertisers seeking to determine whether or not ads designed for one type of media should be recapitulated for use with another type.

Lastly, cross-cultural comparisons are also needed to better understand how attention and arousal differ as a result of environmental influences.

2.4.3 Product/Brand Appraisal

Once consumers have become aware of a product or brand, attention is devoted to appraising (evaluating) multiple aspects of the product/brand for the purposes of judgment and response. Thus, neuromarketing literature pertaining to product and brand appraisal constitutes a second area of research in our taxonomy.

A recent example of using EEG to test brand evaluations, Vecchiato et al. (2011) sought to explore hemispheric differences arising as consumers appraise pleasant versus unpleasant advertising. Participants were asked to rate the "pleasantness" of commercials they could manage to recall 2 h after viewing a documentary video containing the commercials. For remembered commercials, brainwave activity recorded during the commercial was compared to ratings of pleasantness. An asymmetrical increase in theta and alpha wave activity in the left hemisphere was significantly correlated with ratings of ad pleasantness. When ads were not pleasant, such activity was more evenly distributed between hemispheres.

In another example, a concept known as EEG coherence was utilized by Cheung et al. (2010) to examine whether brand name words elicit a higher degree of mental imagery compared to non-brand-related words. EEG coherence is a measure of intra-hemispheric cooperation between distinct regions of the brain. Cheung et al. (2010) cited previous findings in neuroscience literature to propose that high imagery words should manifest themselves as highly coherent beta wave measurements (i.e., similar regardless of the region where EEG signals are being read). On the basis of this theory, the authors were able to associate a higher degree of intra-hemispheric beta wave coherence with brand name words as opposed to concrete words, which suggests that brand name words evoke a substantially greater amount of imagery.

Advertising theory has suggested that contextual information can implicitly affect one's appraisal of a product or brand. For instance, some have suggested that the credibility of an advertising medium can covertly influence subsequent judgments of an advertisement's credibility, a phenomenon known as the "framing effect" (e.g., Gross and D'Ambrosio 2004; Kahneman and Tversky 1984; Tversky and Kahneman 1981). Using fMRI technology, Deppe et al. (2005a) measured brain activity while asking subjects to judge the credibility of 30 different magazine headlines appearing in magazines that had varying credibility. Substantiating extant theory, activity changes were observed in the VMPFC as participants became more or less susceptible to "framing" information. One implication of these findings is that brands deemed credible are processed in a distinctly different neurological way than their less credible counterparts.

In addition, the way in which ads are appraised for credibility, or trustworthiness, may differ as a function of gender, according to Riedl et al. (2010). fMRI activity was monitored as participants viewed eBay offers and evaluated them in terms of trustworthiness. The women in this study were found to activate more brain areas, and different brain areas, than men did as they formulated trust-related judgments. Riedl et al. (2010) suggest that these results confirm previous theory (i.e., empathizing-systematizing theory; see Baron-Cohen et al. 2005) predicting gender differences in the processing of information. A notable feature of this study is that it measures perceptions of trustworthiness directed toward unconventional advertisers (e.g., individual eBay sellers), leading us to wonder whether similar results would occur in response to more established, well-known sources of goods and services (e.g., Fortune 500 companies).

Another fMRI study conducted by Kato et al. (2009) provides compelling evidence that different ad types are not created equal in terms of the neurological processes they elicit. Kato et al. (2009) showed 40 participants both political advertisements from the 1992 US presidential campaign and commercial advertisements for two common brands of cola (i.e., Coke and Pepsi) while imaging their brain activity with fMRI. Negative campaign advertisements were found to elicit increased activation in the dorsolateral prefrontal cortex among participants who were influenced by the ad to lower their ratings of a candidate they originally supported. Similar patterns of activation did not occur when participants viewed negative ads for cola, suggesting that commercial forms of advertisement constitute a different type of social stimuli than politically driven persuasive communication. Earlier research by Yoon et al. (2006) may provide some additional insight into these findings. In the Yoon et al. (2006) study, subjects were imaged with fMRI while they evaluated products and people using specific adjectives. When people were being appraised, increased levels of activation were observed in the medial prefrontal cortex (MPFC), but when products were being appraised, activation was higher in the left inferior prefrontal cortex, which is a known processing site for objects. On the basis of these findings, it seems logical to find that political ads (e.g., selling people) and commercial ads (e.g., selling products) elicit different types of brain activity.

Furthermore, a series of experiments undertaken by Schaefer and Rotte (2007a, b, 2010) have explored how characteristics ascribed to brands can influence different patterns of neurological evaluation as evidenced by fMRI. An initial experiment (Schaefer and Rotte 2007a) exposed participants to familiar (e.g., European) and unfamiliar (e.g., non-European) car manufacturer logos traditionally associated with either luxury or value. Consistent with the findings of an earlier study using a similar paradigm (Schaefer et al. 2006), the evaluation of luxury brands was associated with activation in the MPFC and precuneus, while value brand appraisal resulted in activation of the left superior frontal gyrus as well as the anterior cingulate cortex (ACC). In a second experiment, Schaefer and Rotte (2007b) used a similar methodology but also asked subjects to assess each brand in terms of attractiveness, character as a luxury/sports car, character as a brand of "rational choice," and familiarity. Results indicated that brain activity in the striatum was correlated positively with sports and luxury characteristics, and negatively with rational choice characteristics. In a third experiment (Schaefer and Rotte 2010), pictures of pharmaceutical brands were presented to participants who then completed a semantic differential task (i.e., participants rated a brand regarding pairs of adjectives) while brain activity was monitored with fMRI. Brands loading high on a "social competence" factor showed increased activation in the MPFC while brands yielding high "potency" (i.e., strength) ratings showed decreased activation in the superior frontal gyri, which indicates increased reliance upon working memory processes.

The attractiveness of product packaging has also been shown to affect brain activation. Stoll et al. (2008) measured brain activity using fMRI while participants made decisions about the attractiveness (unattractiveness) of various consumer good packages. An interesting facet of this study was that the authors chose to focus on the *contrast* of attractive to unattractive packages (and vice versa), consistent with consumer choices that often reflect comparisons of multiple products rather than static appraisals of a single product. The authors found that when attractive packages were contrasted with unattractive packages, significant brain activation differences were observed in the occipital lobe and precuneus, regions of the brain associated with the processing of visual stimuli. In contrast, when unattractive packages were contrasted with attractive packages, increased activity was observed in the insula as well as in specific areas of the frontal lobe, regions associated with the analysis of aversive stimuli.

It is clear that various features of products and brands have a notable effect on consumer evaluations. An interesting assumption of this area of research (and related areas of consumer neuroscience) is that aspects of products and packaging vary to determine appraisal while consumer characteristics remain relatively stable. A more holistic approach to studying product/brand appraisal might account for aspects of individual appraisers (e.g., demographic and/or dispositional variables) that contribute to discernible appraisal differences found among consumers. Deeper and broader understanding is bound to emerge as additional aspects of advertising are scrutinized using similar methodologies and techniques.

2.4.4 Product/Brand Preference

As mentioned previously, products and brands are often appraised in comparison to one another for the ultimate purpose of arriving at evaluative judgments. A third research area in neuromarketing directly examines the antecedents of product (brand) preference.

Distinguishing neural activity (both direct and indirect) in response to preferred versus non-preferred brands has been a common approach to this area. For instance, an early study of product preference employed eye-movement tracking technology to compare "chosen" brands to non-chosen counterparts (Pieters and Warlop 1999). An interesting feature of this study was that time pressure was manipulated, such that subjects were either given 7 or 20 s to inspect alternative brand choices. This was done to determine whether eye-movement features (e.g., fixation, saccades) could be used to predict product preference under conditions of time constraint.

Eye-fixation durations were significantly longer for chosen brands, even when controlling for time constraints.

In another example using MEG technology to monitor brain activity during a simulated “shopping trip,” Braeutigam et al. (2004) sought to establish a timeline of neural responses to product choices. Consistent with the findings from previous research (Ambler et al. 2004), men seemed to initially (i.e., at 300 ms) activate right temporal cortices (e.g., spatial memory) while women showed increased activation in left posterior cortices (e.g., category-specific knowledge). Beyond 500 ms, both genders activated right parietal cortices when opting for previously bought items, and left inferior and right orbital cortices when choosing less familiar items. Specific brand preferences did not significantly differ as a function of gender, although the neurological pathways by which these preferences were derived appeared to vary, especially early on.

Further evidence of distinct neural correlates for product preference has emerged from fMRI-based research. Paulus and Frank (2003) imaged brain functionality while having participants complete preference judgment trials (i.e., “which do you like better?”), visual discrimination trials (i.e., “which drink is in a bottle?”), and additional null trials in an effort to isolate neural functioning specifically related to preference judgments. Preference judgment trials corresponded to increased activation of the medial frontal gyrus as well as differential activation of the posterior parietal cortex, anterior cingulate cortex (ACC), and left anterior insula. Additional regions of the brain were implicated in a study of clothing brand preference by Plassmann et al. (2007a, b, c). Subjects for the study were recruited from one of the four stores and then imaged with fMRI while choices pertaining to clothing from that store were compared to decisions made about clothing from the other three stores. When clothing from the target store (i.e., the store subjects were recruited from) was presented, an activation network linking the VMPFC, the striatum, and the anterior cingulate cortex (ACC) was observed. Interestingly, clothing from the other three stores activated an alternative neural network associated with heightened analysis and calculation. Overall, the striatum, an area of the brain connected with reward prediction, exhibited the largest activation differences. The value of findings emerging from studies such as those conducted by Paulus and Frank (2003) and Plassmann et al. (2007b) is their ability to focus future product preference research on specific brain functions. Activation in these areas can be studied to compare and contrast response to various types of product packaging and advertising, providing increased precision for those seeking to forecast the success of one or more approaches.

Defining the essence of product (brand) preference has also been undertaken using fMRI. Plassmann et al. (2008) empirically tested the notion that brand preference is driven by the reduction in ambiguity that occurs as individuals become more familiar with a product. Subjects were told to select between preferred and non-preferred travel agencies to “book” trips to dangerous (i.e., high ambiguity) or non-dangerous (i.e., low ambiguity) travel destinations. Brand information appeared to interact with ambiguity information in the VMPFC as well as the anterior cingulate (ACC), regions of the brain that had previously been linked to brand preference (see Plassmann et al. 2007b). When the subject's favorite brand was among available options, activation differences could be seen in areas of the brain associated previously with product preference. The same areas showed no significant activation differences when the subject's preferred brand was not an option.

Brand preference bias has also been explored with the assistance of neuroimaging methodologies. Replicating a classic brand preference marketing study, McClure et al. (2004) used fMRI to compare the neural activation of participants experiencing anonymous and brand-cued delivery of Coke and Pepsi products. Anonymous delivery yielded a consistent neural response (i.e., regardless of brand preference) in the VMPFC associated with the participant's behavioral choice. Brand-cued delivery led to biased preference corresponding to activation in the hippocampus, dorsolateral prefrontal cortex, and midbrain. An additional replication of this study by Koenigs and Tranel (2008) employed a participant pool comprised of patients with damage to the VMPFC. It was predicted that these patients would not display a preference bias, even when they were exposed to brand information. The results supported this hypothesis, suggesting that the VMPFC plays an integral role in the formulation of brand preferences.

fMRI has yielded numerous insights into aspects of product packaging. In a series of four experiments, Reimann et al. (2010) investigated differences in product preference and neural activation corresponding to aesthetic and standardized forms of packaging. Reaction times of consumers to aesthetic packages were significantly longer, suggesting more effortful processing. Aesthetically packaged products were chosen more frequently than standard-packaged products, even when the standardized packages represented well-known brands. Additionally, higher prices did not deter preference for aesthetic alternatives. Activation differences were present in the nucleus accumbens and the VMPFC, areas of the brain consistent with the perception of rewarding stimuli.

It is important to distinguish research pertaining to elements of product preference from product choice. A notable caveat of each of the studies reviewed in this section is their use of forced choice. Namely, participants were not afforded the option of selecting no alternative, although such an outcome is frequent in real-world settings, and can even occur for products that are highly preferred when unfavorable aspects (e.g., cost, nonnecessity) are determined to outweigh favorable aspects (e.g., aesthetic appeal). The relative importance of each preference aspect likely varies as a function of additional features intrinsic to the person (e.g., individual differences) and extrinsic to the environment (e.g., options a particular store has in stock).

2.4.5 Purchase Behavior

An area of research receiving less attention, relatively speaking, pertains to factors contributing to purchase intent and willingness to pay (WTP). We unite these constructs within our taxonomy under the "purchase behavior" label because both speak to the willingness of consumers to buy a particular product. For example, seeking to establish the neural correlates of WTP, Plassmann et al. (2007c) scanned the brains of hungry patients using fMRI as they submitted bids for the right to eat a variety of junk foods. Significant activity was observed in the medial orbitofrontal cortex (moFC) as well as the dorsolateral prefrontal cortex (dPFC) as decisions pertaining to WTP were made. Specifically, such decisions reflect some calculation of the maximum amount of resources one is willing to part with in order to obtain a desired product. The authors found support for the notion that the moFC plays a critical role in contributing salient goal information to the decision-making process.

Kuhnen and Knutson (2005) also used fMRI to determine whether neural activity could be used to predict when consumers make optimal as opposed to suboptimal financial decisions. Participants completed the Behavioral Investment Allocation Strategy (BIAS) task, where they are prompted to choose between investing in one of the two stocks or a bond. Choosing the bond predictably resulted in any earnings of $1, while choosing either one of the stocks could yield a number of negative (i.e., loss), positive (i.e., gain), or neutral (i.e., zero loss or gain) outcomes. Following their choice, the "earnings" or "loss" resulting from their choice was displayed along with similar data for the remaining two options. Thus, participants were able to compare the consequences of their choice with alternative outcomes, enabling them to anticipate future success or failure and respond with a conservative (i.e., choose the bond) or risky (i.e., choose one of the stocks) approach. Results indicated that activation of the nucleus accumbens, a reward center in the brain, preceded risky choices, while activation of the anterior insula, an avoidance center of the brain, preceded conservative choices. On the basis of these findings, Kuhnen and Knutson (2005) conclude that alternative neural circuits exist to link anticipation of loss or gain to different types of subsequent choices.

Loss aversion appears to be a critical component of intentions to purchase a product. In part to illustrate aspects of reputable fMRI research, Reimann et al. (2011) explored the effects of loss aversion on buying and selling behavior using activation in the amygdala, an area of the brain associated with the processing of negative emotions, as a neural standard for comparison. Participants were asked to establish and manipulate selling and buying prices for mp3 songs. Significantly stronger activation in the amygdala occurred as consumers considered selling prices as opposed to buying prices, consistent with the theory that loss aversion is connected to negative emotional experience.

Future research in this area may benefit from exploring additional theorized and established antecedents and consequences of WTP and purchase intent. For instance, it is our belief that aspects studied in reference to other areas within our taxonomy may be relevant and insightful, including the role of package design and framing effects such as a product's reputation for being a luxury or standard item. Unfortunately, neuromarketing research pertaining to this area continues to be somewhat sparse and limited both in terms of scope and adapted methodology. Furthermore, it is likely that the usage of additional neuroimaging techniques would prove valuable. Brainwave analysis using EEG, for example, could reveal intriguing differences in WTP under conditions of necessity (e.g., hunger) and non-necessity (e.g., routine shopping). We suggest that this lack of coherence does not speak to the limited importance or potential of this area, but rather to the need for additional research and development.

2.4.6 Memory

Memory for marketing stimuli has been studied at length using neural imaging techniques. In particular, two distinct aspects of memory have been targeted. *Recall* consists of memory for an advertised product independent of stimuli pertaining to the product. In contrast, *recognition* refers to memory for an advertised product that is primed when consumers come in contact with the product or associated advertisement materials. Research in this area has largely focused on potential antecedents of product memory with the understanding that advertisements containing these important antecedents will successfully prime consumer memory, and by extension motivate product purchasing behavior.

A more recent neuromarketing example includes Vecchiato et al. (2010a) combining the use of GSR, heart rate, heart rate variability, and dense-array (e.g., 64-channel) EEG to monitor and compare the differences between remembered and forgotten TV commercials. All of these indicators were measured as subjects observed a 30-min documentary containing three commercial interruptions. Within a couple of hours, subjects were interviewed and asked to recall the commercials they remembered and provide a pleasantness rating for each of the commercials they were able to remember. EEG differences were observed in theta wave activity, which was higher and localized in the left frontal brain area for remembered commercials. Heart rate and heart rate variability differences also existed, such that both were higher for remembered and/or pleasant commercials than they were for forgotten and/or unpleasant commercials. Meanwhile, no GSR differences seemed to differentiate remembered and forgotten advertisements.

Beyond messaging elements, celebrity endorsers and spokespersons are also a common memory-associated test found within neuromarketing research. For instance, Klucharev et al. (2008) sought to measure the impact of celebrity endorsement of a product compared to a nonexpert celebrity endorsement in an fMRI experiment. Twenty-four female participants viewed photos reflecting two distinct types of celebrity-product combinations. High-expertise combinations consisted of celebrities that fit the product they were matched with (e.g., Tiger Woods and golf clubs) while low-expertise combinations did not. Participants were asked to indicate whether or not they perceived a link between each celebrity-object pair. One day later, they returned to the lab and their memory was measured. Pairs indicative of celebrity expertise elicited activation in the hippocampus as well as the parahippocampal gyrus, areas of the brain associated with memory formation. Furthermore, high-expertise combinations appeared to impact attitudes by means of activation in the caudate nucleus, a structure of the brain that is believed to be involved in trustful behavior, reward processing, and learning.

Further, the impact of high- versus low-sensation-value advertising was examined by Langleben et al. (2009) using fMRI and measures of recognition memory. Public service announcements (PSAs) advocating against the usage of tobacco were manipulated to reflect either high or low amounts of "message sensation value." Eighteen regular smokers were shown eight anti tobacco PSAs (independently rated for sensation value) as well as eight neutral video clips. Following a 5-min delay, the subjects were shown 128 still frames and then asked to indicate whether or not they had seen the ad depicted in each frame. Surprisingly, the researchers found that frames from low-sensation-value ads were better recognized than frames from high-sensation-value ads. Furthermore, whereas low-sensation ads educed greater pre-frontal/temporal activation, high-sensation ads were connected with greater occipital activation. The potential implications of these findings are noteworthy. Namely, attention-grabbing ads may actually impede subsequent learning and retention.

In summary, research pertaining to recall and recognition of ads is among the earliest to utilize the benefits of direct and indirect methods of neural assessment. Nevertheless, some question remains as to whether or not neural correlates of product memory are also predictive of more basic desired marketing outcomes. For instance, do discernible differences exist between remembered brands and non-remembered brands at the point of sale? It is our belief that the practical value of research exploring various dynamics of recall and recognition would be substantially enriched in the process of connecting it to both proximal (e.g., purchasing) and distal (e.g., brand loyalty) outcomes.

2.4.7 Brand Extension

The sixth and final dimension of our taxonomy is represented by the neuroscientific study of a unique distal outcome of advertising. *Brand extension* is defined by Ma et al. (2007) as "the use of established brand names to enter new product categories or classes" (p. 1031). The benefits of associating a well-regarded brand name with new and additional products are manifold and well summarized by Stewart et al. (2004). In short, successful brand extension is believed to raise the marketability of new (i.e., previously unused) products while potentially further reinforcing the integrity of existing (i.e., already used) products. Relative to other desired marketing outcomes reviewed and organized in this taxonomy, only a small number of studies examine aspects of brand extension. Nevertheless, the limited research conducted in this area is exemplary in terms of the scientific rigor with which it has applied neuroimaging techniques to answering questions of significance to product advertisers. Furthermore, we believe that a sufficient amount of research remains to be done within this area of neuromarketing to sustain its viability as an independent area of interest.

To this point, Qingguo Ma et al. (2007, 2008, 2010) have almost exclusively accounted for the empirical investigations conducted in this area. Dense-array (64-node) EEG has been their technique of choice, with specific brainwave amplitudes comprising their outcome variable(s). A 2007 study by Ma et al. measured the amplitude of brain wave N270, a signal that indicates neural processing of conflicting information, as participants observed different combinations of beverage brand names (stimulus 1) and product categories (stimulus 2). As neural activity was being recorded, participants were asked to indicate the appropriateness of extending the brand depicted in stimulus 1 to the category presented in stimulus 2. Low brand-extension conflict was created by combining beverage names with the categories "beverage" and "snack," while high levels of conflict were induced by pairing beverage names with the categories "clothing" and "household appliance." Consistent with prior research on the properties of N270, higher conflict (beverage name-product category) pairs elicited greater N270 amplitudes than low conflict pairs. These findings suggest that advertising research can utilize EEG and the N270 wave to determine when brand extension *is not* occurring.

In 2008, the same group of researchers (Ma et al. 2008) used a similar methodological paradigm to measure differences registered with regard to a second brain wave of particular significance to neuroscientists, P300. In contrast to the N270 wave, the P300 wave is believed to indicate perceptual similarity. Once again, brain activity was measured with dense-array EEG as subjects indicated the suitability of extending a well-known beverage brand to congruent (i.e., beverage-related) or noncongruent (i.e., non-beverage-related) product categories. Congruent brand-name/product-category pairs resulted in significantly higher P300 amplitudes. Thus, like N270, it appears that P300 can be utilized as a neural indicator of brand extension. Unlike N270, however, the P300 wave appears to be consistent with the *successful* extension of a brand.

A more recent study by Ma et al. (2010) measured N270 amplitude in response to brand name/product type pairs, but added an additional element. Prior to viewing and responding to these pairs, subjects were shown and asked to rate a picture that was either negative or neutral in valence. Ma et al. (2010) hypothesized that brand extension would consistently be rejected when negative emotion was induced. Negative emotion was found to have a significant effect on moderate brand extension, such that participants were less likely to extend a brand when they had been shown a negative as opposed to a neutral picture. However, highly similar and dissimilar brand name/product type pairs were not affected by picture valence. The authors conclude that this is the case because highly similar/dissimilar brand/product pairs do not require the amount of active processing that moderately similar pairs require. Inasmuch as negative emotion is believed to inhibit active processing, the findings of this study make intuitive sense.

In summary, scholarly knowledge of brand extension has already been notably enriched through the use of neuroimaging techniques. Research in this area is needed to distinguish between positive and negative forms of brand extension. In particular, it seems that advertisers would want to promote the extension of brands that are positively regarded by the consumer while inhibiting the extension of brands that have been either neutrally or negatively received. Once the specific neural correlates of positive and negative brand extension have been ascertained, further research could experiment with interventions intended to facilitate or stem the brand extension process.

2.5 Conclusion

The use of neuroscientific research methods can provide marketers with the means to better analyze and understand consumer behavior. These technologies and associated techniques have helped usher in a new renaissance known as neuromarketing. However, we contend in this chapter that the full potential of neuromarketing to meaningfully contribute toward our understanding of consumer behavior has yet to be unlocked. Thus, we attempted to accomplish three goals. First, we provided a practitioner-oriented explanation of common neuromarketing techniques. Second, we updated a contextual framework for neuromarketing research, reclassifying research in terms of targeted marketing outcomes. Third, we have provided numerous suggestions for future research designed to help move the discipline forward.

Although an incredible amount of potential exists for continued exploration and refinement within neuromarketing research, it is our belief that the most intriguing possible avenues for future work exist beyond the purview of the areas previously identified. Meaning, rather than focusing neuromarketing as primarily a measurement paradigm of research, marketers must begin to embrace neuroscientific techniques to confirm, challenge, and construct marketing theory associated with brain activity and the cognitive processing of marketing sensory information. A strong theoretical foundation could reaffirm neuromarketing as a research discipline while contributing greater depth for understanding consumer behavior.

While neuromarketing continues to receive recognition among academics and practitioners, there remains concerns. For instance, a variety of ethical questions have been raised in response to the introduction of neuroscientific measurement techniques associated with commercial for-profit use. First and foremost among them is the issue of personal privacy (Kenning and Linzmajer 2011). Uninformed participants are apt to fear exploitation of their thoughts and feelings and/or violation of their personal autonomy (Murphy et al. 2008; Wilson et al. 2008). Early media attention on neuromarketing is at least in part responsible for this suspicion, propagating fear that people possess a neurological "buy button" that marketers can willfully manipulate without consumer consent to achieve desired gains (e.g., Blakeslee 2004). Walter et al. (2005) note that many if not all of the ethical issues associated with neuromarketing could be easily posed to any form of marketing research. Nevertheless, the need for a guiding code of ethics is clear. Murphy et al. (2008) provide a helpful ethical framework for consumer neuroscience, suggesting provisions that address full disclosure of goals, risks, and benefits as well as the protection of research participants and potentially vulnerable "niche populations." Substantial assistance in developing ethical provisions can be found by consulting neuroscience and neuroethics literature, which reflects attempts on the part of other disciplines to identify and attend to similar issues. These concerns underscore the importance of approaching neuromarketing with careful and deliberate scrutiny and the continued need for research to be conducted openly and made readily available for the public.

References

Aaker DA, Stayman DM, Hagerty MR (1986) Warmth in advertising: measurement, impact, and sequence effects. J Consum Res 12:365–381

Advertising Research Foundation (2013) Neurostandards collaboration project [White Paper]. Retrived from www.thearf.org

Ambler T, Ioannides A, Rose S (2000) Brands on the brain: neuro-images of advertising. Bus Strateg Rev 11(3):17–30

Ambler T, Braeutigam S, Stins J, Rose S, Swithenby S (2004) Salience and choice: neural correlates of shopping decisions. Psychol Mark 21(4):247–266

Ariely D, Berns GS (2010) Neuromarketing: the hope and hype of neuromarketing in business. Nat Rev Neurosci 11(4):284–292

Astolfi L, De Vico Fallani F, Cincotti F, Mattia D, Bianchi L, Marciani MG, Salinari S, Colosimo A, Tocci A, Soranzo R, Babiloni F (2008) Neural basis for brain responses to TV commercials: a high-resolution EEG study. IEEE Trans Neural Syst Rehabil Eng 16(6):522–531

Baron-Cohen S, Wheelwright S, Lawson J, Griffin R, Ashwin C, Billington J, Chakrabarti B (2005) Empathizing and systemizing in autism spectrum conditions. Handb Autism Pervasive Dev Disord 1:628–639

Blakeslee S (2004) If you have a "buy button" in your brain, what pushes it? The New York Times, October 19. http://www.nytimes.com/2004/10/19/science/if-your-brain-has-a-buybutton-what-pushes-it.html?_r=0. Accessed 15 Jan 2016

Bogart L, Tolley BS (1988) The search for information in newspaper advertising. J Advert Res 28:9–19

Boksem MS, Smidts A (2015) Brain responses to movie trailers predict individual preferences for movies and their population-wide commercial success. J Mark Res 52(4):482–492

Bolls PD, Lang A, Potter RF (2001) The effects of message valence and listener arousal on attention, memory, and facial muscular responses to radio advertisements. Commun Res 28(5):627–651

Bolls PD, Muehling DD, Yoon K (2003) The effects of television commercial pacing on viewers' attention and memory. J Mark Commun 9:17–28

Braeutigam S, Stins JF, Rose S, Swithenby S, Ambler T (2001) Magnetoencephalographic signals identify stages in real-life decision processes. Neural Plast 8(4):241–254

Braeutigam S, Rose SP, Swithenby SJ, Ambler T (2004) The distributed neuronal systems supporting choice-making in real-life situations: differences between men and women when choosing groceries detected using magnetoencephalography. Eur J Neurosci 20:293–302

Brickman GA (1976) Voice analysis. J Advert Res 16:43–48

Brickman GA (1980) Uses of voice-pitch analysis. J Advert Res 20:69–73

Britt B (2004) Automakers tap consumer brains. Automot News Eur 9(1):1–22

Cacioppo JT, Petty RE (1983) Social psychophysiology. The Guilford Press, New York

Camerer C, Loewenstein G, Prelec D (2005) Neuroeconomics: how neuroscience can inform economics. J Econ Lit 43(1):9–64

Cheung M, Chan AS, Sze SL (2010) Electrophysiological correlates of brand names. Neurosci Lett 485:178–182

Coates SL, Butler LT, Berry DC (2004) Implicit memory: a prime example for brand consideration and choice. Appl Cogn Psychol 18:1195–1211

Cook IA, Warren C, Pajot SK, Schairer D, Leuchter AF (2011) Regional brain activation with advertising images. J Neurosci Psychol Econ 4(3):147–160

Daugherty T, Hoffman E (2014) eWOM and the importance of capturing consumer attention within social media. J Mark Commun 20(1–2):82–102

Daugherty T, Hoffman E, Kennedy K (2016) Research in reverse: Ad testing using an inductive consumer neuroscience approach. J Bus Res 69(8):3168–3176

Debener S, Ullsperger M, Spiegel M, Engel AK (2006) Single-trial EEG-fMRI reveals the dynamics of cognitive function. Trends Cogn Sci 10(12):558–563

Deppe M, Schwindt W, Kramer J, Kugel H, Plassman H, Kenning P, Ringelstein EB (2005a) Evidence for a neural correlate of a framing effect: bias-specific activity in the ventromedial prefrontal cortex during credibility judgments. Brain Res Bull 67:413–421

Deppe M, Schwindt W, Kugel H, Plassmann H, Kenning P (2005b) Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision-making. J Neuroimaging 15:171–182

Deppe M, Schwindt W, Pieper A, Kugel H, Plassman H, Kenning P, Deppe K, Ringelstein EB (2007) Anterior cingulate reflects susceptibility to framing during attractiveness evaluation. Neuroreport 18(11):1119–1123

Dietvorst RC, Verbeke W, Bagozzi RP, Yoon C, Smits M, Van Der Lugt A (2009) A sales force-specific theory-of-mind scale: tests of its validity by classical methods and functional magnetic resonance imaging. J Mark Res 46:653–668

Donavan T, Minor M, Mowen JC (2016) Consumer behavior. Chicago Business Press, Chicago

Draganski B, Gaser C, Busch V, Schuierer G, Bogdahn U, May A (2004) Neuroplasticity: changes in grey matter induced by training. Nature 427:311–312

Erk S, Spitzer M, Wunderlich AP, Galley L, Walter H (2002) Cultural objects modulate reward circuitry. Neuroreport 13:2499–2503

Fallani FDV, Astolfi L, Cincotti F, Mattia D, Marciani MG, Gao S, Salinari S, Soranzo R, Colosimo A, Babiloni F (2008) Structure of the cortical networks during successful memory encoding in TV commercials. Clin Neurophysiol 119:2231–2237

Fisher CE, Chin L, Klitzman R (2010) Defining neuromarketing: practices and professional challenges. Har Rev Psychiatry 18(4):230–237

Frost R, Stauffer J (1987) The effects of social class, gender, and personality on physiological response to filmed violence. J Commun 37:31–45

Fugate DL (2007) Neuromarketing: a layman's look at neuroscience and its potential application to marketing practice. J Consum Mark 24(7):385–394

Gakhal B, Senior C (2008) Examining the influence of fame in the presence of beauty: an electrodermal "neuromarketing" study. J Consum Behav 7:331–341

Garcia JR, Saad G (2008) Evolutionary neuromarketing: darwinizing the neuroimaging paradigm for consumer behavior. J Consum Behav 7:397–414

Gordon W (2002) The darkroom of the mind: what does neuropsychology now tell us about brands? J Consum Behav 1:280–292

Groeppel-Klein A (2005) Arousal and consumer in-store behavior. Brain Res Bull 67:428–437

Groeppel-Klein A, Baun D (2001) The role of customers' arousal for retail stores: results from an experimental pilot study using electrodermal activity as indicator. Adv Consum Res 28:412–419

Groeppel-Klein A, Germelmann CC, Domke A, Woratschek H (2005) Arousal as a driving force for decision making: empirical results from measuring electrodermal reactions at the point of sale. Adv Consum Res 32:429–430

Grosenick L, Greer S, Knutson B (2008) Interpretable classifiers for fMRI improve prediction of purchases. IEEE Trans Neural Syst Rehabil Eng 16(6):539–548

Gross K, D'Ambrosio L (2004) Framing emotional response. Polit Psychol 25(1):1–29

Harris R (2006) Brain waves. Mark Mag 111(20):15–17

Hazlett RL, Hazlett SY (1999) Emotional response to television commercials: facial EMG vs: self-report. J Advert Res 2:7–23

Herman S (2005) Selling to the brain. Glob Cosmet Ind 173(5):64–66

Herman S (2007) Chemical reaction: nose news. Glob Cosmet Ind 175(1):50–51

Hess EH (1965) Attitude and pupil size. Sci Am 212:46–54

Hess EH (1968) Pupillometrics. In: Bass FM, King CW, Pessemier EA (eds) Applications of the sciences in marketing management. Wiley, New York

Hess EH, Polt GM (1960) Pupil size as related to interest value of visual stimuli. Science 132:349–350

Hoffman E, Daugherty T (2013) Is a picture always worth a thousand words? Attention to structural elements of ewom for consumer brands within social media. NA-Adv Con Res 41:326–331

Hubert M (2010) Does neuroeconomics give new impetus to economic and consumer research? J Econ Psychol 31:812–817

Hubert M, Kenning P (2008) A current overview of consumer neuroscience. J Consum Behav 7:272–292

Kahneman D, Tversky A (1984) Choices, values, and frames. Am Psychol 39(4):341

Kato J, Ide H, Kabashima I, Kadota H, Takano K, Kansaku K (2009) Neural correlates of attitude change following positive and negative advertisements. Front Behav Neurosci 3:1–13

Kenning P, Linzmajer M (2011) Consumer neuroscience: an overview of an emerging discipline with implications for consumer policy. J Consum Prot Food Saf 6:111–125

Kenning P, Plassmann H (2005) NeuroEconomics: an overview from an economic perspective. Brain Res Bul 67(5):343–354

Kenning P, Plassmann H, Ahlert D (2007) Applications of functional magnetic resonance imaging for market research. Qual Mark Res Int J 10(2):135–152

Klucharev V, Smidts A, Fernandez G (2008) Brain mechanisms of persuasion: how ‘expert power’ modulates memory and attitudes. Scan 3:353–366

Knutson B, Scott R, Wimmer GE, Prelec D, Loewenstein G (2007) Neural predictors of purchases. Neuron 53:147–156

Koenigs M, Tranel D (2008) Prefrontal cortex damage abolishes brand-cued changes in cola preference. Scan 3:1–6

Koles ZJ (1998) Trends in EEG source localization. Electroencephalogr Clin Neurophysiol 106:127–137

Koles ZJ, Lind JC, Soong ACK (1995) Spatio-temporal decomposition of the EEG: a general approach to the isolation and localization of sources. Electroencephalogr Clin Neurophysiol 95:219–230

Kroeber-Riel W (1979) Activation research: psychobiological approaches in consumer research. J Consum Res 5(4):240–250

Kroeber-Riel W (1984) Effects of emotional pictorial elements in ads analyzed by means of eye-movement monitoring. Adv Consum Res 11:591–596

Krugman HE (1965) The impact of television advertising: learning without involvement. Public Opin Q 29(3):349–356

Krugman HE (1971) Brain wave measures of media involvement. J Advert Res 1:3–9

Krugman DM, Fox RJ, Fletcher JE, Fischer PM, Rojas TH (1994) Do adolescents attend to warnings in cigarette advertising? An eye tracking approach. J Advert Res 34:39–52

Kuhnen CM, Knutson B (2005) The neural basis of financial risk taking. Neuron 47:763–770

LaBarbera PA, Tucciarone JD (1995) GSR reconsidered: a behavior-based approach to evaluating and improving the sales potency of advertising. J Advert Res 5:33–53

Lang A, Borse J, Wise K, David P (2002) Captured by the world wide web: orienting to structural and content features of computer-presented information. Commun Res 29:215–245

Langleben DD, Loughead JW, Ruparel K, Hakun JG, Busch-Winokur S, Holloway MB, Strasser AA, Cappella JN, Lerman C (2009) Reduced prefrontal and temporal processing and recall of high “sensation value” ads. Neuroimage 46(1):219–225

Lee N, Broderick AJ, Chamberlain L (2007) What is ‘neuromarketing’? A discussion and agenda for future research. Int J Psychophysiol 63:199–204

Lin CH, Tuan HP, Chiu YC (2010) Medial frontal activity in brand-loyal customers: a behavior and near-infrared ray study. J Neurosci Psychol Econ 3(2):59–73

Lohse GL (1997) Consumer eye movement patterns on yellow pages advertising. J Advert 26:62–74

Ma Q, Wang X, Dai S, Shu L (2007) Event related potential n270 correlates of brand extension. Neuroreport 18:1031–1034

Ma Q, Wang X, Shu L, Dai S (2008) P300 and categorization in brand extension. Neurosci Lett 431:57–61

Ma Q, Wang K, Wang X, Wang C, Wang L (2010) The influence of negative emotion on brand extension as reflected by the change of N2: a preliminary study. Neurosci Lett 485:237–240

Marques dos Santos JP, Martins M, Ferreira HA, Ramalho J, Seixas D (2016) Neural imprints of national brands versus own-label brands. J Prod Brand Manag 25(2):184–195

McClure SM, Li J, Tomlin D, Cypert KS, Montague LM, Montague PR (2004) Neural correlates of behavior preference for culturally familiar drinks. Neuron 44:379–387
Morin C (2011) Neuromarketing: the new science of consumer behavior. Society 48:131–135
Morris JD, Klahr NJ, Shen F, Villegas J, Wright P, He G, Liu Y (2009) Mapping a multidimensional emotion in response to television commercials. Hum Brain Mapp 30:789–796
Mucha T (2005) Why the caveman loves the pitchman. Business 20 6(3):37–39
Murphy ER, Illes J, Reiner PB (2008) Neuroethics of neuromarketing. J Consum Behav 7:293–302
Nelson RG, Schwartz D (1979) Voice-pitch analysis. J Advert Res 19:55–59
Nighswonger NJ, Martin CR (1981) On using voice analysis in marketing research. J Mark Res 18:350–355
Ohme R, Reykowska D, Wiener D, Choromanska A (2009) Analysis of neurophysiological reactions to advertising stimuli by means of EEG and galvanic skin response measures. J Neurosci Psychol Econ 2(1):21–31
Ohme R, Matukin M, Szczurko T (2010a) Neurophysiology uncovers secrets of TV commercials. Der Markt 49:133–142
Ohme R, Reykowska D, Wiener D, Choromanska A (2010b) Application of frontal EEG asymmetry to advertising research. J Econ Psychol 31:785–793
Ohme R, Matukin M, Pacula-Lesniak B (2011) Biometric measures for interactive advertising research. J Interact Advert 11(2):60–72
Paulus PM, Frank LR (2003) Ventromedial prefrontal cortex activation is critical for preference judgments. Neuroreport 10:1311–1315
Perrachione TK, Perrachione JR (2008) Brains and brands: developing mutually informative research in neuroscience and marketing. J Consum Behav 7:303–318
Pieters R, Warlop L (1999) Visual attention during brand choice: the impact of time pressure and task motivation. Int J Res Mark 12:1–16
Pieters R, Wedel M (2004) Attention capture and transfer in advertising: brand, pictorial, and text-size effects. J Mark 68:36–50
Pieters R, Rosbergen E, Wedel M (1999) Visual attention to repeated print advertising: a test of scanpath theory. J Mark Res 36:424–438
Plassmann H, Ambler T, Braeutigam S, Kenning P (2007a) What can advertisers learn from neuroscience? Int J Advert 26(2):151–175
Plassmann H, Kenning P, Ahlert D (2007b) Why companies should make their customers happy: the neural correlates of customer loyalty. Adv Consum Res 34:1–5
Plassmann H, O'Doherty J, Rangel A (2007c) Orbitofrontal cortex encodes willingness to pay in everyday economic transactions. J Neurosci 27(37):9984–9988
Plassmann H, Kenning P, Deppe M, Kugel H, Schwindt W (2008) Neural correlates of brand choice under uncertainty: the role of brand trust. J Consum Behav 7:360–367
Potter RF, La Tour MS, Braun-La Tour KA, Reichart T (2006) The impact of program context on motivational system activation and subsequent effects of processing a fear appeal. J Advert 35(3):67–80
Pradeep AK (2010) The buying brain: secrets for selling to the subconscious mind. Wiley, New York
Reimann M, Zaichkowsky J, Neuhaus C, Bender T, Weber B (2010) Aesthetic package design: a behavioral, neural, and psychological investigation. J Consum Psychol 20:431–441
Reimann M, Schilke O, Weber B, Neuhaus C, Zaichkowsky J (2011) Functional magnetic resonance imaging in consumer research: a review and application. Psychol Mark 28(6):608–637
Reimann M, Castaño R, Zaichkowsky J, Bechara A (2012a) Novel versus familiar brands: an analysis of neurophysiology, response latency, and choice. Mark Lett 23(3):745–759
Reimann M, Castaño R, Zaichkowsky J, Bechara A (2012b) How we relate to brands: psychological and neurophysiological insights into consumer–brand relationships. J Consum Psychol 22(1):128–142
Reynolds J (2006) Editorial. J Target Meas Anal Mark 14(3):189–190

Riedl R, Hubert M, Kenning P (2010) Are there neural gender differences in online trust? An fMRI study on the perceived trustworthiness of E-Bay offers. MIS Q 34(2):397–428
Rossiter JR, Silberstein RB (2001) Brain-imaging detection of visual scene encoding in long-term memory for TV commercials. J Advert Res 41:13–21
Rossiter J, Silberstein R, Nield G, Harris P (2001) Brain-imaging detection of visual scene encoding in long-term memory for TV commercials. J Advert Res 41(2):13–21
Rothschild ML, Hyun YJ (1990) Predicting memory for components of TV commercials from EEG. J Consum Res 16:472–478
Rothschild ML, Thorson E, Reeves B, Hirsch JE, Goldstein R (1986) EEG activity and the processing of television commercials. Commun Res 13(2):182–220
Rothschild ML, Hyun YJ, Reeves B, Thorson E, Goldstein R (1988) Hemispherically lateralized EEG as a response to television commercials. J Consum Res 15:185–198
Sanbonmatsu DM, Kardes FR (1988) The effects of physiological arousal on information processing and persuasion. J Consum Res 15:379–385
Schaefer M, Rotte M (2007a) Thinking on luxury or pragmatic brand products: brain responses to different categories of culturally based brands. Brain Res 1165:98–104
Schaefer M, Rotte M (2007b) Favorite brands as cultural objects modulate reward circuit. Neuroreport 18(2):141–145
Schaefer M, Rotte M (2010) Combining a semantic differential with fMRI to investigate brands as cultural symbols. Scan 5:274–281
Schaefer M, Berens H, Heinze HJ, Rotte M (2006) Neural correlates of culturally familiar brands of car manufacturers. Neuroimage 31:861–865
Schafer A (2005) Buy This. Sci Am Mind 16(2):72–75
Shamoo AE (2010) Ethical and regulatory challenges in psychophysiology and neuroscience-based technology for determining behavior. Account Res 17:8–29
Singer E (2004) They know what you want. New Sci 183(2458):36–37
Smith K, Dickhaut J (2005) Economics and emotion: institutions matter. Games Econ Behav 52:316–335
Stafford JE, Birdwell AE, Van Tassel CE (1970) Integrated advertising: white backlash. J Advert Res 10:15–20
Stallen M, Smidts A, Rijpkema M, Smit G, Klucharev V, Fernandez G (2010) Celebrities and shoes on the female brain: the neural correlates of product evaluation in the context of fame. J Econ Psychol 31:802–811
Stayman DM, Aaker DA (1993) Continuous measurement of self-report of emotional response. Psychol Mark 10:199–214
Stewart AJ, Pickering MJ, Sturt P (2004) Using eye movements during reading as an implicit measure of the acceptability of brand extensions. Appl Cogn Psychol 18:696–709
Stoll M, Baecke S, Kenning P (2008) What they see is what they get? An fMRI study on neural correlates of attractive packaging. J Consum Behav 7:342–359
Telpaz A, Webb R, Levy DJ (2015) Using EEG to predict consumers' future choices. J Mark Res 52(4):511–529
Treleaven-Hassard S, Gold J, Bellman S, Schweda A, Ciorciari J, Critchley C, Varan D (2010) Using the P3a to gauge automatic attention to interactive television advertising. J Econ Psychol 31:777–784
Tversky A, Kahneman D (1981) The framing of decisions and the psychology of choice. Science 211(4481):453–458
Van Bortel FJ (1968) Commercial applications of pupillometrics. In: Bass FM, King CE, Pessemier EA (eds) Application of the sciences in marketing management. Wiley, New York
Van den Abeele P, MacLachlan DL (1994) Process tracing of physiological responses to dynamic commercial stimuli. Adv Consum Res 21:226–232
Vecchiato G, Astolfi L, De Vico Fallani F, Cincotti F, Mattia D, Salinari S, Soranzo R, Babiloni F (2010a) Changes in brain activity during the observation of TV commercials by using EEG, GSR, and HR measurements. Brain Topogr 23(2):165–179

Vecchiato G, Astolfi L, Tabarrini A, Salinari S, Mattia D, Cincotti F, Bianchi L, Sorrentino D, Aloise F, Soranzo R, Babiloni F (2010b) EEG analysis of the brain activity during the observation of commercial, political, or public service announcements. Comput Intell Neurosci 2010:1–7

Vecchiato G, Fallani FDV, Astolfi L, Toppi J, Cincotti F, Mattia D, Salinari S, Babiloni F (2010c) The issue of multiple univariate comparisons in the context of neuroelectric brain mapping: an application in a neuromarketing experiment. J Neurosci Methods 191:283–289

Vecchiato G, Toppi J, Astolfi L, Fallani FDV, Cincotti F, Mattia D, Bez F, Babiloni F (2011) Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. Med Biol Eng Comput 49:579–583

Walter H, Abler B, Ciaramidaro A, Erk S (2005) Motivating forces of human actions: neuroimaging reward and social interaction. Brain Res Bull 67:368–381

Walton C (2004) The brave new world of neuromarketing is here. B & T (Australia), 19 November, p 22

Wang YJ, Minor MS (2008) Validity, reliability, and applicability of psychophysiological techniques in marketing research. Psychol Mark 25(2):197–232

Watson PJ, Gatchel RJ (1979) Autonomic measures of advertising. J Advert Res 19(3):15–26

Wedel M, Pieters R (2000) Eye fixations on advertisements and memory for brands: a model and findings. Mark Sci 19:297–312

Weinstein S, Weinstein C, Drozdenko R (1984) Brain wave analysis. Psychol Mark 1:17–42

Wilson RM, Gaines J, Hill RP (2008) Neuromarketing and consumer free will. J Consum Aff 42(3):389–410

Yoon C, Gutchess AH, Feinberg F, Polk TA (2006) A functional magnetic resonance imaging study of neural dissociations between brand and person judgments. J Consum Res 33:31–40

Yu-Ping C, Nelson LD, Ming H (2015) From "where" to "what": distributed representations of brand associations in the human brain. J Mark Res 52(4):453–466