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Brains and brands: Developing mutually informative research in neuroscience and marketing

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- *Advances in neuroimaging technology have led to an explosion in the number of studies investigating the living human brain, and thereby our understanding of its structure and function. With the proliferation of dazzling images from brain scans in both scientific and popular media, researchers from other fields in the social and behavioral sciences have naturally become interested in the application of neuroimaging to their own research. Commercial enterprises have long been interested in the prospects of literally "getting inside the heads" of customers and partners, with a variety of goals in mind. Here we consider the ways in which scholars of consumer behavior may draw upon neuroscientific advances to inform their own research. We describe the motivation of neuroscientific inquiry from the point of view of neuroscientists, including an introduction to the technologies and methodologies available; correspondingly, we consider major questions in consumer behavior that are likely to be of interest to neuroscientists and why. Recent key discoveries in neuroscience are presented which will likely have a direct impact on the development of a neuromarketing subdiscipline and for neuroimaging as a marketing research technique. We discuss where and how neuroscience methodologies may reasonably be added to the research inventory of marketers. In sum, we aim to show not only that a neuromarketing subdiscipline may fruitfully contribute to our understanding of the biological bases of human behavior, but also that developing this as a productive research field will rest largely in framing marketing research questions in the brain-centric mindset of neuroscientists.*

Introduction

The field of neuroscience seeks to understand the structure and function of the brain: how it encodes and represents the environment, and how it controls the body. The underlying theoretical framework investigates how brain states give rise to behavioral states, such that understanding the mechanisms of neural computation will provide a greater understanding of the classical relationship between stimulus and response. The field of neuroscience is broad, including inquiry into the

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brain at all levels, from examining the assemblies of proteins that make up ion channels in the membranes of neurons,[1] to recording the spiking activity of individual brain cells by inserting microelectrodes into animals' brains, to inferring the cortical regions contributing to particular tasks by scanning behaving humans with functional magnetic resonance imaging (fMRI). The study of consumer behavior is unlikely to be directly informed by the very interesting research targeting the physical and chemical properties of individual neurons, but it is extremely likely to be able to develop mutually informative research with cognitive neuroscience. This branch of neuroscience seeks to understand the neural mechanisms underlying complex thoughts, such as reasoning, decision making, object representation, emotion, and memory, which overlap with marketing notions such as positioning, hierarchy of effects, brand loyalty, and consumer responses to marketing.

The advent of functional neuroimaging has made an incredible impact on cognitive neuroscience by allowing us to peer inside the brains of living, behaving human beings and make inferences about the processes underlying their behavior. Brain scans, however, differ in nontrivial ways from classical scientific imaging tools such as microscopes, cameras, or X-ray machines. Unlike those tools, the images of brain activity generally published in fMRI studies are not actual pictures of the brain in action. Instead, these images depict the results of complex statistical comparisons between the brain's metabolic activity during, for example, two different experimental conditions. That is to say, it is currently impossible to put someone into an fMRI scanner and know immediately what they are doing or thinking at any given moment. (The analysis of functional neuroimaging data requires explicit *a priori* knowledge of either the structure of the task or representative patterns of brain activity in an individual.) In order to carry out good science, the productive application of neuroscience methodologies to companion fields such as consumer behavior and market research a will require an understanding of the limitations of these techniques and the questions they can reasonably be employed to answer from the perspective of neuroscientists. This paper focuses primarily on summarizing this perspective with respect to some of the important questions in marketing and consumer behavior. Based on our backgrounds as a neuroscientist and marketing researcher, we aim to develop a synthesis of the theoretical interests of each of our fields and outline some promising, mutually informative domains in which this synthesis could be fruitfully applied. We begin by taking some of the major topics in marketing and consumer behavior and framing them in the way that a neuroscientist might approach them. We then summarize some striking recent advances in neuroscience using neuroimaging techniques, with a focus on the ways these methodologies might be employed to answer marketing and consumer behavior questions. Finally, we consider potential implications that might arise in the development of neuromarketing programs for real-world market research and marketing applications.

Understanding neuroscience from the perspective of a neuroscientist

The field of neuroscience is predicated on the study of the structure and function of the brain. Note that this is distinct from the study of the *mind*, which is the purview of psychology and cognitive science. It is commonly declared that "the mind is what the brain does"; but this is only partly true. The brain also does many things that are separate from the mind, including controlling autonomic functions such as regulating heartbeat, initiating a fear response, and regulating sleep/wake cycles, to name just a few. Therefore, marketers inter-

[1]Readers who are new to neuroimaging and interested in more detail about the technical, biological, and methodological points raised in this paper are directed to the introductory neuroimaging text *Functional Magnetic Resonance Imaging*, by S.A. Huettel and colleagues (2004, Sinauer Associates, Sunderland, Massachusetts).

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ested in collaborating with neuroscientists and introducing neuroimaging techniques into their research programs on marketing and consumer behavior should be prepared to answer the essential question: what will this study tell us about the brain? (In addition to, of course, how can we then apply this knowledge in marketing or advertising?) An excellent example of cross-domain collaboration to form a brain-centric question is a recent study by Plassmann *et al*. (2008), which examined the effects of marketing actions (pricing) and the congruence between neural activity and perceived reward. In this study, participants were presented with sample wines and their prices, and rated the pleasantness of each while their brain was scanned with fMRI. Regardless of the real cost of the wine, subjects reported a more pleasant tasting experience as the wines' indicated price increased. Remarkably, activity in reward-related regions in the subjects' brains also increased when they believed they were drinking more expensive wine, suggesting a cognitive factor unrelated to the actual taste sensation (here, the marketing action of pricing) could actually affect subjects' perception of pleasantness. Even though this study replicates a well-established psychological phenomenon, it is unique in showing that not only psychological responses, but also physiological responses, are influenced by consumers' perceptions of a product based on a manipulation of a basic element of the marketing mix. This is an excellent case study in how collaborative research in marketing and neuroscience can be mutually informative. To marketers, the question, ''How does the price of a product affect its perceived quality?'' might be theoretically provocative in that field, but neuroscientists will be interested in asking this question in a different way, for example: ''how is reward-related neural activity affected by cognitive factors independent of the stimulus?'' Note that these questions are largely the same – both are interested in the same effects in the same populations, but the marketers' question focuses on behavior, whereas the neuroscientists' focuses on the brain. In order to pique the interest of colleagues who only have eyes for gray and white matter, framing a marketing research question in a brain-centric way is paramount. In the rest of this section, we will consider several of the key questions that appeal to cognitive and behavioral neuroscientists, as well as brain regions involved (**Figure 1**) and tools used to study them (**Table 1**). One way to describe neuroscientific inquiry is through three broad components: *localization, connectivity*, and *representation*, which we will consider in turn. A basic understanding of neuroscientific research is necessary before its techniques can be applied to marketing research questions.

Localization examines which parts of the brain are necessary or sufficient for various behaviors and abilities. For example, we know the hippocampus is necessary for forming certain kinds of memory (McGaugh, 2000), the amygdala is necessary for fear responses (Maren and Quirk, 2004), and the superior colliculus is sufficient for controlling eye movements (Hanes and Wurtz, 2001). In the brain's cortex, we know there are, broadly, sensory cortices that perceive the environment, association cortices that process such stimuli, and motor regions that output behavior. Cortex can further be divided into sensory regions for vision, audition, and touch, and motor regions for hands, legs, and tongues, and so on. Whether there exist further distinctions, including the specialization of smaller parts of cortex for ecologically (behaviorally) relevant stimuli, remains the subject of ongoing research programs. There is strong evidence for localized brain regions underlying capacities such as face perception (Kanwisher *et al*., 1997), language (Caplan and Gould, 2003), and place recognition (Maguire *et al*., 1997), as well as more abstract abilities like reasoning about the knowledge of others (Saxe and Kanwisher, 2003) or self-control (Miller and Cohen, 2001), but it is generally unknown – and a subject of great interest – to what extent such local specialization is functionally significant or simply epiphenomenal. Functional neuroimaging, in particular fMRI,

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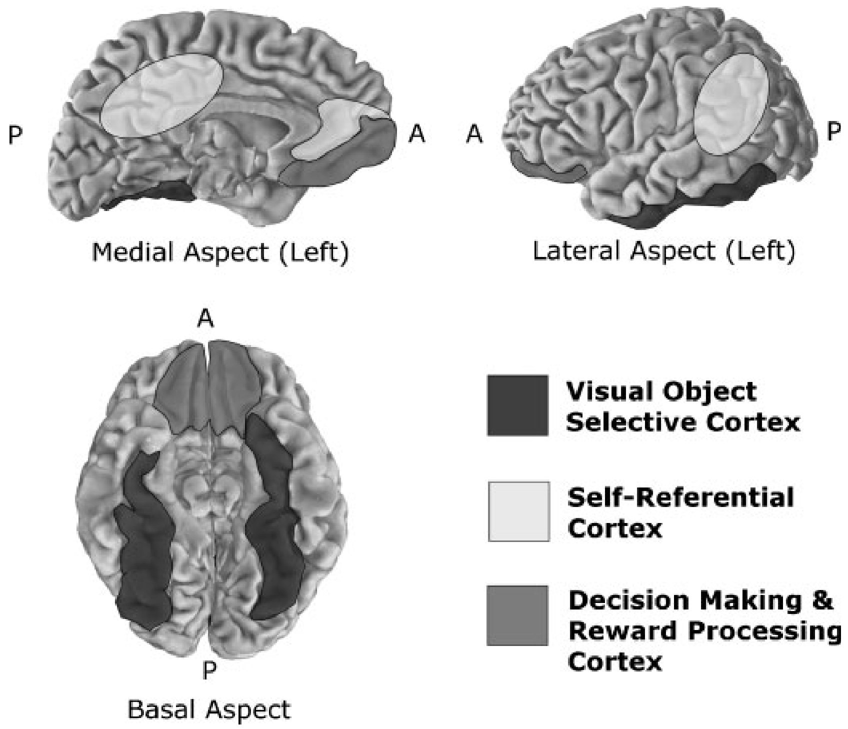

Figure 1. Cortical regions of interest for neuromarketing research. Three views of the cortical surface of the human brain are shown. Shadings indicate functions of particular interest in neuromarketing research that these regions are thought to subserve. Visual object selective cortex predominates the inferior temporal gyrus (ITG). Self-referential cortex includes the superior parietal lobe, posterior cingulated gyrus, and medial prefrontal cortex. Decision making and reward processing cortex includes ventromedial prefrontal and orbitofrontal cortex. The medial aspect shows the brain as if it were bisected along a vertical axis between the eyes. The lateral aspect shows the brain from the left hand side. The basal aspect shows the brain from the bottom looking up. In these views, the cerebellum and brainstem are removed. A = Anterior (toward the nose), P = posterior (toward the back of the skull). These regions are drawn coarsely; individual brain anatomy and functional localization varies somewhat from person to person.

provides an excellent tool for investigating localization (see Table 1 for descriptions of neuroimaging and psychophysical methods). By computing differences in regional blood oxygenation in the brain across different conditions, fMRI can reveal regions that are more metabolically active (and are therefore held to play a larger functional role) during one condition versus another (Friston, 1997).

Connectivity considers the ways in which different brain regions pattern together for information processing. For example, a region in the occipital lobe called V4 shows specificity for processing certain kinds of visual stimuli, and parts of the prefrontal cortex are responsible for directing and focusing attention. Interestingly, when these attention-directing parts of the prefrontal cortex are activated, the sensitivity of V4 neurons to specific visual stimuli can be either enhanced or inhibited (Armstrong *et al.*, 2006). Abnormalities in connectivity can result in behavioral impairments. It has been hypothesized, for instance, that the speech condition stuttering might result from errors in feedback between speech perception (auditory) regions and speech production (motor) ones (Tourville *et al.*, 2008). Connectivity can be measured in fMRI by looking at the cross-correlations of activity in regions of interest, and through a number of sophisticated statistical techniques such as effective or functional connectivity analyses. Networks identified by these analyses can include those with direct anatomical connections (e.g., as identified via diffusion tensor imaging (DTI), see Table 1), although not

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Table 1. An overview of predominant psychophysiological techniques

	Acronym	Physical measure	Applied measure	Temporal resolution	Spatial resolution
Neuroimaging technologies					
Magnetic resonance imaging	MRI	Change in energy state of hydrogen	Grey and white matter	Days[a]	< 1–3 mm
Functional magnetic resonance imaging	fMRI	Blood oxygenation level	Metabolic activity	Seconds	1–5 mm
Diffusion tensor imaging	DTI	Magnetic diffusion gradient of water	White matter tracts	Days[a]	1 mm
Positron emission tomography	PET	Radioactive 2-deoxyglucose	Metabolic activity	Seconds	3–5 mm
Near infrared spectroscopy	NIRS	Blood oxygenation level	Metabolic activity	Seconds	2 cm
Computed tomography	CT	X-ray absorption	Grey and white matter	NA	< 1 mm
Magnetoencephalography	MEG	Magnetic fields	Population neural activity	Milliseconds	Centimeters
Electroencephalography	EEG	Electrical fields	Population neural activity	Milliseconds	Centimeters
Transcranial magnetic stimulation	TMS	NA[b]	Accuracy and reaction time[b]	Milliseconds[b]	> 1 cm[b]
Other psychophysiological techniques					
Voice pitch analysis	VPA	Vocal cord vibration	''Arousal''	Fractional seconds	NA
Galvanic skin response	GSR	Electrical resistance	''Arousal''	Fractional seconds	NA
Eyetracking		Corneal reflectivity	Spatial attention	Milliseconds	NA

Neuroimaging techniques are those which can directly image the structural and functional properties of the brain. Additional techniques listed provide information beyond that available in ''standard'' behavioral experiments. Temporal resolution = the fastest rate of changes that can be measured by this technique. Spatial resolution = the minimum possible distinction between locations.

[a]MRI and DTI are primarily measures of brain structure; however, it has been shown that even the anatomy of the brain is highly plastic, and changes in its anatomy can be measured in the same individual over time (Draganski *et al.*, 2004).

[b]TMS (and also recently transcranial direct current stimulation, TDCS) uses an oscillating electromagnetic field to stimulate the brain locally, rather than measure neural activity. The effects of TMS intervention are assessed indirectly through behavioral responses such as accuracy or reaction time. Although some recent studies suggest TMS can differentially affect adjacent cortical areas (e.g., < 2 cm apart; Pitcher *et al.*, 2007), the effective spatial resolution remains unknown.

necessarily so. Investigating connectivity can reveal neural contributions to behavior that might otherwise not be evident when considering localization alone, thus revealing further the underlying complexity of such behaviors.

Representation examines the codes with which information is stored and processed in the brain, sometimes including the attempt to ''read out'' or interpret those codes. Studies of representation consider neural patterns, from the spiking activity of just a handful of neurons (e.g., Harper and McAlpine, 2004) all the way to distributed activation patterns among MRI voxels (Haynes and Rees, 2006; Norman *et al.*, 2006) or the waveforms of electroencephalograms (EEGs), both of which represent the collective responses of hundreds of thousands of neurons. Understanding neural representation is crucial for a number of applied neuroscience endeavors, in particular, reading out the moment-by-moment thoughts and experiences of individuals to gauge their mental states as target stimuli (e.g., advertisements, products, etc.) unfold around them in real time.

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Motivating neuroscience research with questions of marketing, advertising, and consumer behavior

Scholars of marketing and consumer behavior should be aware that many neuroscientists are unlikely to realize the marketing field is much broader than just developing advertisements. Fairly or not, such misperceptions are likely to place upon market researchers the additional onus of having to justify the relevance of neuroscience to their own research programs. Neuroscientists, like all scientists, will be enthralled by interesting new ideas, but bringing them onboard for productive and successful neuromarketing endeavors will require framing projects in such a way that appeals directly to their interest in the structure and function of the brain. The most recent formal definition of marketing includes the characterization that ''marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large,'' (Keefe, 2008), which entails a number of interesting directions for neuroscientific research. Humans with limited time and other resources must learn to behave optimally in a contemporary environment awash with competing products and services, and therefore the functional architecture of our brains will have been substantially developed to manage such ''consumer'' tasks. We will consider a number of potential questions regarding the relationship between the individual and the market that would be mutually informative for both marketing and neuroscience within the neuroscientific parcellation of ''localization, connectivity, representation'' described above.

Many of the principal aspects of marketing research (much less marketing) have yet to be localized to any particular part of the brain. While this may be due to the exceptionally complex behaviors represented in consumer activities, it is also because social neuroscience has only recently begun to emerge as a subdiscipline (Ochsner and Lieberman, 2001). All four components of the ''marketing mix'' (product, price, place, and promotion), as they are perceived by consumers, could be potentially interesting perspectives from which to study functional neural architectures. One such question is that of *value*, the delivery of which is fundamental to all four mix components. From models in both animals and humans, the neural structures and pathways responsible for generating sensation of rewards have been clearly identified (Schultz, 2000; also see Figure 1). However, outside of corporeal factors such as food, drugs, and sex, little is known about how neural reward signals are modulated, how development and experience might selectively shape neural stimulus-reward relationships, and how reward signals are to be understood in a social context.

In a recent study, Fliessbach and colleagues (2007) showed that activity in these reward centers is modulated not only by absolute reward magnitude, but also relative reward magnitude compared to the financial earnings of other experiment participants. Such socially comparative reward-seeking behavior has the potential to explain the neural bases of consumers' differential responses to fads, luxuries, and necessities. In related work, Elliot and colleagues (2003) showed that different components of the reward network respond differentially based on the mere presence of a reward, its magnitude, or whether it is relatively small or relatively large. These results could likely be used to inform research into the neural bases of price perception: are the prices of products represented monotonically from inexpensive to expensive? Or are consumers' brains encoding more nuanced notions of price, such as ''inexpensive for a sports car'' or ''expensive for a burrito?'' Indeed, as discussed above, the results of Plassmann *et al*. (2008) indicate that the prices of certain products can have a direct effect on the neural representation of their perceived reward. In the same way, it is unknown how additional value-adding parameters such as *promotions* can affect neural reward signals. How does activity in

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neural reward centers change with respect to value-adding features such as rebates, coupons, sales events, etc.? (For example, do sweepstakes directly recruit neural circuitry for reward, or is there underlying activity associated with risks and expectations, e.g., gambling?) Do these factors contribute linearly or by scaling the reward signal, and which regions (e.g., Elliot *et al*.'s binary, linear, or extreme-detecting processes) are ultimately responsible for consumers' decision-making behavior? The closest marketing has come to these questions is the study of consumers' uses of heuristics in decision making, none of which are based on evidence from the specific neural regions subserving these behaviors (e.g., Bettman, 1979).

One well-documented *representation* effect in neuroscience is strong electrical responses to unexpected stimuli. Using EEG, researchers in a variety of fields have shown that when the brain encounters a situation that it must suddenly re-evaluate – essentially, performing a mental ''about-face'' – the resultant electrical activity can indicate how unexpected the situation or event was. Investigating such ''expectancy-violation'' event-related potentials (ERPs) is likely to be useful in a variety of market-oriented research paradigms. For example, Cohen *et al*. (2007) showed that expectancy-violation ERPs could be modulated by the likelihood of a reward. This result was also demonstrated by Hewig *et al*. (2007) who investigated reward responses in a simulated game of blackjack: larger electrical responses were elicited when the expected reward was greater. It is easy to see how such a paradigm could be applied to comparing a consumer's expectation about a product to its actual performance, or customers' expectancy relationships between a product's price and perceived quality. For example, Meyvis and Janiszewski (2002) demonstrated in a series of consumer behavior experiments that irrelevant product information decreases the positive response of consumers to a product (i.e., how likely they are to believe a product will provide the desired benefit). Researchers interested in what sorts of information consumers value with regards to different products could utilize expectancy-violation ERPs to compare the relative benefits of presenting different kinds of information when marketing various products. Such a translational use of ERPs could help identify optimally successful promotional messages, including for instance many of the predictions of the elaboration likelihood model (ELM), (Petty *et al*., 1991).

Another important question regarding value is its perceptual development. Clearly not all consumers find all products equally enticing, and this difference in relative value is certainly encoded in the activity of regions like the ventral striatum. However, it is unknown how the reward system develops such preferences over time. Small and colleagues (2001) examined changes in reward signal from eating chocolate, showing that as consumption continued to increase, reward activity was replaced with aversion (suggesting there is a neural basis for ''too much of a good thing,'' or the ''wearout effect'' in advertising). This modulation of reward signal in the very short-term could provide a platform for further investigation of neural bases for personal preference: how do experiences or media (advertisement) exposure lead consumers to prefer one brand or product over another; and, once the preference is established, how difficult is it to alter? Some research has even suggested increased activation of reward pathways by culturally preferred (e.g., luxury) brands (Schaefer and Rotte, 2007). Given the substantial difference in individuals' preferences for brands and products, especially with regard to self-definition (e.g., Berger and Heath, 2007), it would be very interesting to see whether activity in reward pathways could predict individuals' unique hierarchies of brand preference. Understanding the neural dynamics of value (reward) will put us in a much better position to answer these questions in the marketplace. Beyond consumers, reward networks may play a role in inter-organization marketing transactions. At least one study has shown that activity in reward networks can be modulated by the perceived

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moral character (trustworthiness) of partners in a trading simulation (Delgado *et al.*, 2005).

Several questions of *connectivity* can be raised when considering the *place* and *promotion* components of the marketing mix. Of the plethora of ways marketers can undertake promotion, we will consider one specifically here: direct marketing. As we collect more sophisticated data on individuals' consumption patterns, say via credit cards, online marketplaces, or supermarket membership discount programs, we can more effectively tailor and convey advertisements directly to specific individuals. As the popularity of database marketing techniques grows, we can reasonably ask whether consumers are differentially encoding marketing directed at them individually versus more general advertising media. Recent advances in social/affective neuroscience have demonstrated that there are several regions of the brain that are ''self-oriented''; that is, they appear to encode information specifically relevant to oneself (see Figure 1, and also Gillihan and Farah, 2005, for a review). These regions respond preferentially to stimuli that evoke a sense of self or other shared feature within the observer. For example, Kelley and colleagues (2002) asked individuals to rate the accuracy of trait descriptions and found that an area of the brain called the medial prefrontal cortex (MePFC) was more active when subjects were making decisions about themselves versus other people, a neural analog of situational influences on consumer behavior. Mitchell and colleagues (2005) found similar effects in the MePFC when looking at other people, depending on how similar to him/herself the observer thought they were. The effectiveness of database marketing could be tested by examining the patterns of connectivity between self-referential brain centers like the MePFC and reward-processing regions like the striatum. It may be the case that individuals experience greater perceived reward when a greater sense of self is evoked. In particular, Berger and Heath (2007) showed that consumers often seek brands that allow them to differentiate themselves from the majority, evoking self-identity through unique purchasing behavior. By extending the behavioral work of Berger and Heath through a carefully constructed neuroimaging experiment, there is the potential to describe the functional relationship between self-referential and reward-processing brain regions – a question of substantial interest to neuroscientists as well as marketers.

Another interesting question of *representation* has to do with the category membership of products, be they goods (objects or consumables), services, or other ''intangibles'' such as software, insurance, or music; or, in some cases, combinations of these. Marketing differs from classic category concepts in several ways: many otherwise unrelated objects and ideas may be unified under the scope of a brand. For example, the category ''McDonald's'' is likely evoked by any of the following otherwise unrelated concepts: the golden arches icon, a yellow-suited clown, or two all-beef patties with special sauce. Recent advances in fMRI have begun to allow us to look deeper into specific category membership by considering patterns of activation across broad stretches of cortex. Haxby *et al.* (2001) showed that there were discernable patterns of activity across visual cortex for a variety of objects such as faces, chairs, houses, shoes, scissors, and even cats. More sensitive research using direct intracellular recording from monkeys (Kiani *et al.*, 2007) has shown that neural activity organizes categories hierarchically: neural activity to monkey faces and human faces has more in common than to tools or pens, which also evoke activity distinct from cars or butterflies. As stated above, brand membership cuts across conventional category structure. By using new methods for analyzing functional neuroimaging data such as information theory, support vector machines, and sophisticated extensions of cross-correlation techniques such as those introduced by Haxby and colleagues or Kiani and colleagues, we could conceivably investigate how supracategorial membership affects the neural representation of product-related objects. Is there a region in the brain where activity to a picture of McDonald's golden

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arches more resembles that of a Big Mac than the St. Louis arch? Moreover, this approach could be used to investigate the perceived similarity of products: do the neurons in consumers' inferior temporal lobe think the McDonald's Big Mac is more like Burger King's Whopper or a Wendy's Double? When people go to Taco Bell, are they really ''thinking outside the bun?'' or is neural activity relating to tacos really more like that of hamburgers after all? Recently, in a series of noteworthy experiments, Berger and Fitzsimons (2008) revealed the compelling effect of the prominence of various concepts in the environment on brand preference and purchasing behavior. For example, varying the exposure of subjects to the color orange or images of dogs made them more likely to prefer orange-themed products (such as orange soda or Reese's candy) or animal-themed apparel (namely Puma shoes). There are likely to be very interesting neural correlates to these phenomena that could be described by manipulating the mutual information between an environmental feature (such as dogs on the street) and a particular product (Puma sneakers), and identifying which brain regions are responsible for representing/integrating that information.

In another interesting study, Berger *et al.* (2007) looked at the relationship between the perception of the quality of a brand and the number of products offered. They showed that brands encompassing a number of related products were seen by consumers as having more expertise (core competency), and therefore being of higher quality. But how can we determine empirically whether the various products offered under the umbrella of a given brand are homogeneous enough to positively affect the perception of that brand? Ma *et al.* (2007) report a study in which they use ERPs to investigate similarity in brand extension. In a straightforward design, they presented subjects with a familiar brand followed by a novel product. The resulting ERPs indicated the extent to which customers found the novel product appropriate for the given brand. Products that deviated significantly from those expected from a given brand (e.g., dish detergent from a soft-drink company) elicited different ERPs than products more appropriate to brand extension (e.g., a new soft drink). The importance of carefully considered brand extension is well documented. Meyvis and Janiszewski (2004) described the relationship between the diversity of a brand's product portfolio and its ability to successfully extend its identity to novel products. Brands with a narrower product portfolio are less likely to be able to extend the perception of quality associated with their brand to novel products that differ significantly from those in their portfolio. Similar protocols to that used by Ma and colleagues could be designed to look for even more nuanced details of brand extension in both research and real-world marketing applications.

Enhancing understanding of consumer behavior through discoveries in neuroscience

In this section we briefly present some of the most compelling issues in neuroscience research today. Here we hope mainly to serve as a point of edification for scholars interested in combining neuroscience and marketing research, thereby stimulating their own ideas about how to combine these exciting advances to inform both the design of neuromarketing studies as well as the understanding of consumer behavior more generally.

Mirror neurons

In some species of primates, putatively including humans, there exists a special class of cells in the prefrontal and parietal cortices which respond not only during the execution of an action (such as picking up an object) but also during the *observation* of the same goal-oriented action by another individual (Rizzolatti *et al.*, 1996). Dubbed ''mirror neurons,'' these cells may provide a biological basis for internally simulating the outside world, including especially the goals and intentions of others. Although the existence of such mirror

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neurons in humans is only hypothetical (neuroscientists generally consider it unethical to stick electrodes directly into the brains of other humans), there is a growing body of research showing special cortical networks underlying imitative behavior (Iacobini *et al.*, 1999). The activation of such an imitative/simulative network in consumers' brains could provide clues to how they encode the behaviors portrayed by actors in advertisements. In similar work, Pulvermüller (2005) has shown that motor regions activate not only when performing actions, but also when *verbal descriptions* of the same actions are heard. A neural metric based on this phenomenon could be used for instance to measure how effectively product spokespersons or endorsers convey the use of a product or advantage of a brand. In recent consumer behavior research, Ashton-James *et al.* (2007) described interesting interpersonal effects of social mimicry, suggesting a behavioral (and therefore neural) integration between systems responsible for perceiving the action of others and processing self-referential information. How the putative mirror-neuron system is integrated with the self-referential networks described earlier is a question ripe for the development of a productive neuromarketing collaboration.

Experiences change the physical structure of the brain

Much exciting research has emerged following the discovery that the adult brain was constantly growing new neuronal connections as individuals gained knowledge and skills. This is true not only in regions like the hippocampus, which is responsible for forming some memories, but also in higher levels of the cortex. In addition to work showing that patterns of neural activity change during skill learning (e.g., Wong *et al.*, 2007), there is also evidence that the *physical* structure of the brain can change with experience. In one compelling study by Draganski and colleagues (2004), it was found that brain regions responsible for processing visual motion grew significantly larger after subjects learned to juggle. Certain products could take advantage of methodologies that measure the change in brain structure (e.g., voxel-based morphometry, Ashburner and Friston, 2000) to make very persuasive claims: ''science shows that our product helps your brain grow!'' Of course, experience-related differences could also produce areas of more theoretical research, such as the effects of extended television viewing or video game playing on one's brain.

Certain abilities exhibit a developmental timecourse

Some of our most basic human abilities appear largely dependent on experience early in life when neural pathways are grown and pruned most rapidly. Language, for example, is one such ability. Individuals who are not exposed to language early in life demonstrate serious impediments in its acquisition later (Pinker, 1994), which partially contributes to why it is so difficult to learn a foreign language as an adult. Experiments with animals demonstrate that an impoverished sensory environment as infants leads to serious sensory impairments as adults because the neural structure to represent those environments does not develop. The same is true for human beings; infants who lack experiences with visual input to the appropriate part of their brain exhibit impairments in recognizing faces later in life (Le Grand *et al.*, 2003). This leads to the question of how consumer brand loyalty and purchasing habits might be acquired in childhood, and the extent to which they are plastic in adulthood. This also raises an ethical issue of the effects of child-directed marketing, since this is the point when they may be establishing lifelong neural representations and, consequently, purchasing habits.

Emotion and cognition may share a fundamental neural link

Despite years of economic theory being based on the ''rational consumer,'' substantial recent

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evidence shows that emotional responses are integral to the decisions individuals ultimately make. For example, patients with damage to the ventromedial prefrontal cortex, part of the brain implicated in expectation and relating rewards to their causes, are substantially impaired in decision making abilities (see Bechara, 2004, for a review). Emotions can similarly play a significant role in perception, attention, and memory formation even in normal (unimpaired) individuals (see Dolan, 2002, for a review). This suggests that despite calls for more informative advertising, marketers and advertisers would do well to continue to attend to the emotional responses of consumers to their products in order to optimize value delivery. Indeed, Meyvis and Janiszewski (2002) demonstrated that any information which does not directly suggest a product's benefit to the consumer will inadvertently weaken that product's perceived benefit instead.

Utilizing neuroscience methodology in real-world marketing applications

As we have seen, marketing and neuroscience are poised to make substantial theoretical and practical contributions to one another's investigations. Yet no marriage of academic fields comes easily, and merging such apparently disparate fields as marketing and neuroscience faces several practical concerns. First, it is commonly held that neuroscientists display considerable skepticism toward the development of a neuromarketing subdiscipline (e.g., Lee *et al*., 2007). This may be due in part to the skeptical attitude inherent in scientists and necessary for critically reviewing the claims of new research. However, another part of this skepticism may arise from a failure to communicate what exactly marketing entails, from a research point of view. If neuroscientists see ''neuromarketing'' only as a tool advertisers intend to use to subvert consumers, tricking them into buying products by attempting to ''short-circuit'' their brains (regardless of whether this is even possible), it is no surprise that they recoil in ethical disgust. For example, one of the premier medical journals, *The Lancet: Neurology* published an anonymous editorial (''Neuromarketing: beyond branding,'' 2004) expressing considerable skepticism about whether neuroscience technologies could be appropriately applied to market research.

Despite the huge potential for mutually informative research programs, unilateral endeavors on the part of marketers to utilize neuroscience methodologies have done nothing to assuage the fears of scientists. In November 2007, ''researchers'' from a private neuromarketing firm published a letter in the opinion and editorial (Op-Ed) section of the *New York Times*, ostensibly interpreting the neural responses of swing-voters' brains measured by fMRI to explain how they ''really'' felt about the prospective candidates in the upcoming U.S. elections (Iacobini *et al*., 2007). The scientific basis of this letter was highly suspect, to say the least. As mentioned in our Introduction, it is impossible to take the data from a brain scan and use it as a *post hoc* description of what a person ''actually'' was thinking or feeling. By making statements associating patterns of activation across brain regions with specific emotional responses, the authors summarily exceeded the bounds of responsible, accurate interpretation of the data. The patterns of neural activity elicited under any given task are extremely complex, and attempting to interpret them in the absence of a particular hypothesis and statistical test between comparison conditions amounts to nothing short of making up ''just so'' stories or divining meaning from reading tea leaves (Liberman, 2007). Immediately after the letter's publication, a collection of several of the most preeminent neuroscientists replied in the *New York Times* with what in the tempered world of scientific discourse amounted to a scathing response (Aron *et al*., 2007). Additionally, the premier scientific journal *Nature* published their own editorial which was highly critical of the entire enterprise and its association with private neuromarketing ventures (''Mind games'', 2007).

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As seen in this and a number of other modern public scientific debates, bad science elicits nothing short of a visceral reaction from scientists. Clearly, there is a wrong way to develop a subdiscipline of neuromarketing (see also Grimes, 2006). As we have discussed extensively above, good neuromarketing research necessarily includes informative questions about both behavior and brain structure/function. If nothing else, the question of peer-review is not insignificant.

Another major factor to be aware of in neuroscience research is the existence of a "neuroscience effect," in which claims become more believable solely by appealing to a neural explanation. In a recent study, Weisberg and colleagues (2008) showed that bad explanations of psychological phenomena became significantly more believable simply by putting the explanation in a neural context. This effect was true for all participants except trained neuroscientists (who, as mentioned before, were substantially more skeptical of any explanation than any other group). Similar results are reported by McCabe and Castel (2008) with respect to the presence of brain imaging pictures in research studies. Such effects set up an important ethical issue: if basing a claim in brain research – or an advertising claim reportedly based on brain research – makes it "extra" believable, we as ethical scientists and practitioners must be even more sure of the veracity of that claim. Over-interpreting results because of an appeal to a brain-basis is not only a problem for third parties, but for a researcher as well. In an *Advertising Age* opinion piece, Feit (2007) suggests that neuromarketing will revolutionize the field of marketing by allowing us to look beyond our surface (i.e., behavioral) differences to "the ripples and folds of the human brain" where "we are built (and function) in largely the same way." In any field of experimentation we risk over-interpreting our results, but in neuroscience especially, where we are coming to learn that the patterns of functional activity in our brains are just as unique as we are (and, in fact, are the basis for such surface differences), we must be exceedingly cautious in assuming one brain, or a small sample of brains, adequately represents all other brains.

There is also the question of financing neuroscientific endeavors. Unlike basic behavioral research, which encompasses much marketing and advertising research, functional neuroimaging (with the exception of EEG) is extremely expensive. The equipment cost of running a one-hour research MRI is generally US$500 or more, not including compensation to the subject. MRI research requires a dedicated imaging facility with not only the scanner equipment (which requires extensive upkeep, including continuously replacing the liquid helium used to cool the supermagnet), but also a staff including at least a radiologist and physicist to maintain the equipment and supervise the research. The cost of such a facility is certainly beyond the capability of an individual investigator or laboratory, and often beyond the means of any single department. Usually such facilities are shared by an entire medical or educational institution, or shared among several institutions. Money for performing neuroscientific studies generally comes from government sources, such as the National Institutes of Health and the National Science Foundation in the Untied States. Accepting federal money to conduct research comes with additional stipulations, such as making the original data available to other researchers for peer review. This might pose a predicament for organizations hoping to conduct proprietary research in conjunction with a neuroscientist receiving public money. Similarly, conducting neuroimaging studies is essentially collecting medical information about the participants, and may likely fall under additional statutory and other legal guidelines for storing and sharing medical records (e.g., the Health Insurance Portability and Accountability Act (HIPAA) in the United States).

The analysis of functional neuroimaging data is also not straightforward. Individuals properly versed in the appropriate analytical tools and techniques not only need to understand the statistical assumptions that go into the models and analyses, but also need extensive knowledge of the biology of the brain –

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especially its hemodynamics – and a certain amount of physics to understand how the fMRI magnet interacts with the various types of tissue and other matter found in the human head. (For a complete list of the technical information that should accompany any published fMRI study, see Poldrack *et al.*, 2008.) Although cheaper, the analysis of EEG data also carries extensive assumptions about the underlying neuronal activity generating the electrical fields, not to mention its spatial localization (see Table 1). Moreover, many of the most popular software packages for analyzing fMRI data stipulate they be used for scientific research only. The license agreement for one such program, *FreeSurfer* (http://surfer.nmr.mgh.harvard.edu/), from the Martinos Center for Biomedical Engineering in Boston, Massachusetts, explicitly states that the software is not to be used for commercial applications. The use of some other, say in-house, software package by a private organization invariably leads to questions of validity and replication due to the lack of, and need for, peer-review.

Finally, one of the most critical questions facing prospective neuromarketers is: ''do we really need to use brain-imaging to find our answer? Or can a behavioral task do the job just as quickly, accurately, and less expensively?'' Naturally, there is considerable appeal in producing the dazzling brain scans to accompany a behavioral claim, but in many conditions, such imaging does not add anything new to the conclusion. Halliday (2007) notes that when one company sought to use brain imaging to support a simultaneous behavioral study, the two methods came to identical conclusions. In a case such as this, the company would have been prudent to forgo the expensive imaging component and rely specifically on the behavioral results, since it is the consumers' behavior they were really interested in at the end of the day. Unless the study specifically addresses a question of the structure or function of the human brain, researchers should carefully consider whether neuroimaging is actually contributing meaningful data toward the project's goals.

Concluding remarks

In this paper we have sought to explain the means by which neuroscientists and marketers might align their fields for developing mutually informative research. Undertaking this co-operation will necessarily involve marketers learning to think like neuroscientists, especially in learning to ask the sorts of questions that will entice neuroscientists to collaborate: questions about the structure and function of the brain. We have reviewed some of the major focuses of marketing research and how these topics are very much in line with the types of research being done in neuroscience today. We have seen that all four elements of the marketing mix are likely to have a number of direct neural correlates within the broad domains of neural localization, connectivity, and representation. We have also discussed some of the most exciting recent discoveries in cognitive and behavioral neuroscience, and how these discoveries might serve to inform marketing research and application. Finally we have attempted to illustrate some of the key issues that are inhibiting the development of a successful neuromarketing subdiscipline, as well as the mindsets that can help overcome them. Ultimately, we believe a marriage of neuroscience and marketing research is likely to produce some very important discoveries into the function of the human brain and how it is adapted to our complex, commercial environment. However, successfully instituting neuromarketing research requires adopting a strongly scientific mindset to avoid the pitfalls of over-interpretation and illusionment, as is too often the case of commercial activities and communication.

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