# What can advertisers learn from neuroscience?

Hilke Plassmann
*California Institute of Technology*
Tim Ambler
*London Business School*
Sven Braeutigam
*University of Oxford*
Peter Kenning
*Muenster School of Business and Economics*

The insights of neuroscience are only just becoming available for the study of advertising. This paper seeks to consolidate the contribution so far. Advertising works in two ways: it may trigger some immediate response and/or change the respondent's brand memories in some way that influences later behaviour. This paper addresses the latter process. In other words, advertising first changes brand equity, and brand equity, in turn, later affects behaviour. The paper outlines the four main techniques of functional brain imaging and reported research in this area, its limitations and the opportunities for new research. Whether the contribution to date is seen as modest or substantive is a lesser question than what neuroscience could do for our longer-term understanding of how advertising works. Neuroscientists and advertisers need to work together so that research investigates how ads are processed, how brand memories are stored and the subsequent behaviour effects relative to the intentions of the advertisers.

## Introduction

Advertising has been the subject of formal research for over a century but the powerful insights of neuroscience are only just becoming available. This paper seeks to consolidate the contribution so far. Advertising, if it is effective at all, works in two ways. It may elicit a direct response, such as calling a number shown on the TV screen, and/or it changes the respondent's mindset such that behaviour may be affected at a later date. This paper is concerned with this second type of response. Whether we call this

International Journal of Advertising, 26(2), pp. 151–175

Published by the World Advertising Research Center, www.warc.com

mindset 'brand memories' or 'brand equity', the point to notice is the time gap between the perception of the advertising and actual behaviour. Weilbacher (2003) castigated advertising practitioners for ignoring everything we have learned about how ads work during the last 40 years and perpetuating old myths. He suggested that advertising, if it works at all, can be seen as the net addition to consumer brand memories.

One broad observation shapes everything that follows: the human brain is nothing like a computer. It is capable of processing information in a rational fashion to produce logical answers. We can multiply two by two just like a computer can, but our brains do not do that in the same way the computer does and it does many other things a computer cannot. Bechara and Damasio (2005) proposed that decision making of the shopping or dining type (as distinct from habitual or corporate) may depend on feelings with little if any rational involvement except for post-rationalisation. Contrary to traditional economic thinking, we are not trying to make decisions solely on the basis of calculating and maximising our utilities but also on the basis of emotions and what feels 'right'. If our brains were merely calculators, advertising would have little to contribute. In addition, we know from cognitive psychology that emotions play an important role for memory processes: they can help us to learn and to remember (Erk *et al.* 2003). Note that we are only interested in brand-related memories. An ad may leave a strong memory but if it is not connected with brand memories, then it will not affect brand-related behaviour.

The paper begins with brand equity because this is what advertising is usually seeking to change. Brand equity may be clear as a concept but it is not easy to measure. Neuroscience may one day, but not yet, help us with those measures. We then step from the ideal to the practical and compare the current technologies, which allow researchers to scan brains while subjects are receiving ads or (virtually) shopping or making other decisions that may have been influenced by the ads. Four main techniques can monitor ad reception and decision making but not the presumably dormant period in between. The brain may be reordering our memories and linkages but, if so, little is known of how (or why). We then review reported research in this area, its limitations and the opportunities for new research. Finally, we draw conclusions.

## Brand equity

The collection of brand memories can be described as what marketing researchers have labelled 'brand equity' – the asset created by good marketing. This is to a large extent what consumers have in their heads about the brand (Aaker 1991, 1996; Keller 1993). Keller and Lehmann (2003, p. 28) define brand memories as 'everything that exists in the minds of customers with respect to a brand (e.g. thoughts, feelings, experiences, images, perceptions, beliefs, and attitudes).' This mindset influences consumers' purchasing decisions and, across a broad group of customers, it affects the market performance of the company.

Brand equity is a relatively new concept in marketing. It can be seen as the asset that marketers, and especially advertisers, are trying to build. It represents, in a sense, the buying habit, and most marketers are more concerned about repeat purchases and customer lifetime value than they are about the immediate next purchase.

Aaker (1991) decomposed brand equity into loyalty, awareness, perceived quality, associations and 'other proprietary brand assets'. This last may appear circular but his intention was to include any attributes that gave competitive advantage. Keller noted that brand equity lay with all stakeholders, e.g. shareholders, and focused attention, as we do in this paper, on customers, by which he meant consumers: '*customer-based brand equity* is defined as the differential effect that brand knowledge has on the consumer response to the marketing of the brand' (Keller 1998, p. 45). In other words, if eight people would buy a plain, unbranded bar of chocolate and 16 would do so in its branded packaging, the eight uplift can be attributed to brand equity.

Note that the two-stage view of advertising effects set out in this paper makes no timing distinction *within* each stage. While some of the research discussed later includes timelines for the processing of ads and/or decision making, our concern is with the overall build-up of brand equity through advertising and its application in decision making. In much the same way, this paper does not compare non- with new or habitual ad or brand users, except to the extent that we are trying to match brand equity with parts of the brain 'lighting up'. This area of research has nothing yet to say about advertising frequency, for example.

Most of our knowledge of a brand comes from our personal experience of consuming it, but our brand knowledge also comes from formal marketing communications and informal word of mouth. The questions in this paper therefore are to do with how advertising builds this brand knowledge, or equity, and how brand knowledge affects consumer behaviour. If neuroscience can help us in these areas, we would be closer to effective measurement of advertising performance.

## Current technology

### *The main techniques*

The working human brain relies heavily on communication between nerve cells facilitated by a complex, energy-consuming electrochemical signalling scheme. Conceptually, current brain imaging techniques can be distinguished according to whether (1) electric and magnetic fields associated with neuronal signalling or (2) its metabolic (energy-consuming) manifestations are monitored. The electrochemical aspects are discussed first.

Electrical pulses are sent along a neuron's axon, reaching a junction called a synapse. At the near side of the junction, the electrical pulses trigger the release of chemical substances, known as neurotransmitters, which diffuse across a small cleft before reaching the far side of the synapse attached to the next neuron. There, the neurotransmitters give rise to relatively strong and long-lasting synaptic currents. These currents determine the target neuron's response, which may result in a new burst of electrical pulse sent along its axon to the next cell in the network (Thompson 1993).

These synaptic currents within nerve cells are accompanied by both magnetic fields and compensatory currents outside the cells. The magnetic fields penetrate through the intervening brain tissues, skull bones and skin into the space surrounding the head. The compensatory currents can also be measured by voltages between points on the scalp. In contrast to the magnetic fields, these voltages are, to a noticeable degree, distorted by variations in tissues and the skull, such as the eye cavities (Kandel *et al.* 2000).

The coherent activity of many thousands of neurons produces electrical potential differences across the scalp, detectable using purpose-made electrodes in conjunction with high-quality signal amplifiers. This only moderately expensive, readily available technology is known as electroencephalography (EEG, literally, recording the electrical activity of the brain). The (scalp) EEG is a non-invasive and silent technology directly sensitive to neuronal activity. The time resolution of the EEG is limited by the hardware, where, typically, a voltage is recorded every 1 to 3 milliseconds (Lopez da Silva & van Leeuwen 1987).

The coherent activity of many neurons also produces magnetic fields detectable outside the head. The strength of these fields is extremely small, typically one part in one billion of the Earth's magnetic field. To date, the only instrument with the sensitivity required is the superconducting quantum interference device (SQUID) coupled to a pick-up coil. The resultant, much more expensive technology is known as magnetoencephalography (MEG). MEG and EEG are conceptually similar technologies, but MEG offers superior signal quality in conjunction with very high time-resolution (Sato 1990; Malmivuo & Plonsey 1995).

Another approach is to monitor the metabolic processes induced by changes in neural activity. Since 1890 researchers have noted that physiological functions in the brain respond regionally to brain activity (Roy & Sherrington 1890). Positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) measure several of these physiological functions, including changes in metabolism and metabolic by-products, blood flow, blood volume and blood oxygenation. Simply phrased, an event such as a sensory or cognitive task leads to an increase in regional neuronal activity, which in turn leads to an increase in local energy (e.g. glucose) consumption and in local dilation of blood vessels and thus a change in regional cerebral blood flow (Noll 2002).

Within this chain of physiological effects, PET relies on the spatial dispersion of radionuclides during the metabolism of glucose. This means that the subject is given a minute amount of a radioactive pharmaceutical, which is similar to naturally occurring glucose, with the addition of a radioactive fluorine atom. Gamma radiation produced from the decaying fluorine is detected by the PET scanner and shows in fine detail the metabolism of glucose in the brain. As with the techniques above, the patient is comfortable, conscious and alert. As PET is employing radioactive agents, the applications for non-clinical studies are rather limited.

However, fMRI is a non-invasive technique, which has been widely applied in neuropsychological studies investigating neural correlates of various experimental conditions in healthy subjects. The most commonly used fMRI technique, called 'BOLD-fMRI' (blood-oxygen-level-dependent fMRI), uses changes in blood oxygenation and thus differing magnetic properties of regional cerebral blood flow to detect the fMRI signal (Kwong *et al.* 1992; Ogawa *et al.* 1992).

### *Comparison of techniques*

EEG, MEG, PET and fMRI are all fairly complex techniques, which require specific expertise and a longer time period for data acquisition as compared to traditional methods used in advertising research. They differ with respect to their advantages and disadvantages for advertising research (see Table 1 for an overview).

EEG, MEG and fMRI have negligible risks for subjects as they are all non-invasive, i.e. they require no penetration or ingestion of drugs or markers (Huesing *et al.* 2006). However, PET is invasive because radioactive contrast agents need to be applied, which is the major disadvantage

**Table 1: Overview – advantages/disadvantages of different techniques**

| Technique | EEG | MEG | PET | fMRI |
|---|---|---|---|---|
| What is measured | Electric fluctuations | Magnetic fluctuations | Changes in metabolism | |
| **Advantages/disadvantages** | | | | |
| 1. Potential risks for participants | ++ non-invasive | ++ non-invasive | – invasive<br>– claustrophobic anxiety | ++ non-invasive<br>– claustrophobic anxiety<br>– noise<br>– no ferromagnetic implants |
| 2. Temporal resolution | ++ very good | ++ very good | – limited | – limited |
| 3. Spatial resolution | – limited | – limited | + good | ++ very good |
| 4. Costs of data collection | ++ very cost-efficient | – expensive | – expensive | – expensive |
| 5. Complexity of data analysis | – moderate to high complexity* | – moderate to high complexity* | – relatively high complexity | – relatively high complexity |

Source: partly adapted from Baillet *et al.* 2001.
Notes: + and – indicate positive and negative features within in a row respectively; *dependent on research objective; this table is simplified but provides an overview for non-technical readers

of this technique. MEG and fMRI both use magnetic fields and thus test subjects with ferromagnetic implants/body parts may have to be excluded for reasons of safety or data integrity. Also, subjects lie in a relatively narrow bore during fMRI and PET scans and care should be taken that they do not suffer from claustrophobia. Because of the relatively high scanner noise with some techniques, and the need for communication between researcher and subject in all techniques, subjects are usually given headphones.

The temporal resolution of EEG and MEG is the major advantage of these techniques when the researcher is interested in the temporal structure of an activation pattern. The temporal resolution of PET (20 $s^{-1}$ min) and fMRI (5–8 s) is rather poor and therefore their application for understanding the temporal connectivity of different brain areas is limited.

However, the spatial resolution of PET (2–10 mm) and fMRI (1–3 mm) highlights the brain areas that are involved in computing the experimental condition(s). We refer to regions of the brain ‘lighting up’ not, of course, because they actually do illuminate but because it is a useful metaphor for communicating the effects. It is important to have high resolution and also to measure changes in deeper brain structures such as the nucleus accumbens (see Figure 1), which is involved in emotion processing. EEG/MEG techniques have a limited, model-dependent spatial resolution.

The main advantages of EEG over MEG, PET and fMRI are the lower costs of data acquisition and equipment and its reduced complexity in data analysis. MEG, PET and fMRI equipment and the necessary technical personnel need to be rented for up to US$800 per hour. Furthermore, data analysis is less standardised than for EEG.

Each technique could be leveraged based on the specific research question of interest. From this comparison, it is apparent that EEG, MEG and fMRI are the most useful methods.

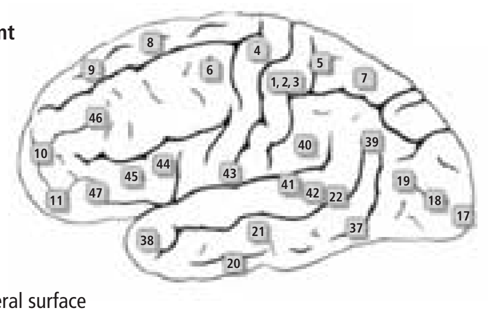
## Research findings

This section takes a slightly sceptical view of the literature. We mean no disrespect to the authors but the early stages of any cross-disciplinary exploration are bound to throw up false leads and it may be helpful to indicate concerns where they exist. We review previous research in two areas:

**Figure 1: Brain areas involved in recent advertising-related research**

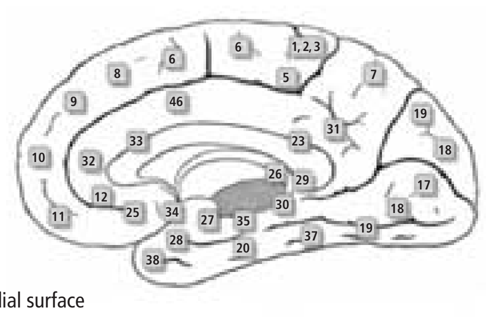
(a) Schematic Brodmann areas (BA) involved in previous work

**Front**




Lateral surface

- Anterior cingulate cortex: BA 24, 32, 33
- Fusiform gyrus (or face area): BA 37
- Posterior cingulate cortex: BA 23, 31
- Posterior parietal cortex: BA 5, 7, 39, 40
- Primary visual cortex: BA 17
- Prefrontal cortex: BA 8, 9, 10, 11, 44, 45, 47, 47
  - Dorsolateral parts: 9, 46
  - Orbitofrontal parts: 11
  - Ventromedial parts: 9, 10, 11, 32




Medial surface

Images taken from: http://commons.wikimedia.org/wiki/image:Gray726-Brodman.png
Source material is not subject to copyright

(b) Schematic cortical and sub-cortical brain areas involved in previous work

**Front** **Back**

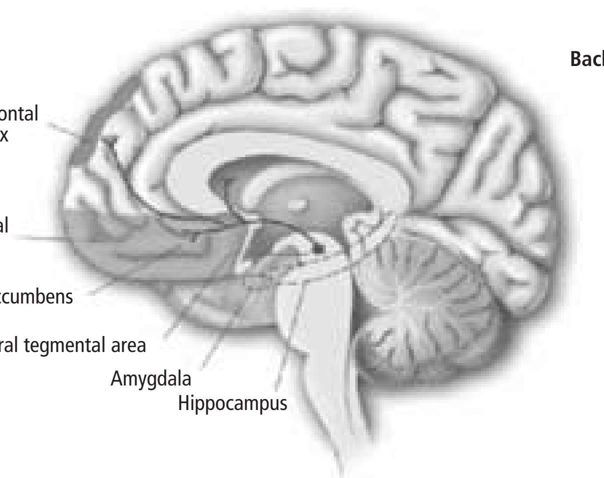



Image taken from: http://library.thinkquest.org/04oct/01639/vn/health/popup/nucleus.html
Source material is not subject to copyright

advertising inputs (perception) and the later influence of brand memories on behaviour, e.g. buying decisions.

### *Advertising inputs*

Steady-state probe topography (a variant of EEG developed in Melbourne) was used while subjects viewed frames from new TV commercials (Rossiter *et al.* 2001). Scenes held on-screen for 1.5 seconds or longer performed better in an unannounced recognition test one week later. After controlling for scene duration, scenes that elicited the fastest brain activity in the left frontal hemisphere were also better recognised. The authors concluded that the transfer of visual information from short-term memory to long-term memory takes place in the left hemisphere, not the right hemisphere as previously believed. Accordingly they suggested that highly memorable TV commercials could be selected by testing the speed of electrical response in the left-brain hemisphere. However, this was challenged by Crites and Aikman-Eckenrode (2001), mainly on the grounds that the findings were not reliable and might be explained by extraneous variables. Moreover, parallel research published by some of these authors using the same techniques – for example, Silberstein *et al.* (2000) – found front-to-back differences rather than left-to-right.

Similarly, in Kemp *et al.* (2002) both pleasant and unpleasant emotions were associated with transient, widespread and bilateral frontal latency reductions. Unpleasant images were also associated with a transient bilateral anterior frontal amplitude decrease. According to the authors, these findings support previous literature in terms of overlap in frontal neural activity in response to pleasant and unpleasant relative to neutral stimuli.

A different method has been proposed to detect putative ‘branding moments’ within TV commercials (Young 2002). These short periods within the advertisement are hypothesised to do much of the ‘work’ in creating advertising effects. The method is based on a rather rudimentary measure of (mental) engagement derived from fundamental alpha (8–13 Hz), beta (13–30 Hz), and theta (4–7 Hz) rhythms present in the EEG. A high correlation was reported between the rhythms and picture sorting. Taken together, these findings might suggest that there are identifiable moments of ‘special’ importance within a given TV commercial. That must be true in the general sense that some parts of any ad are more engaging than others. It seems unlikely that there is any such pattern across all ads.

A study employing MEG investigated the neuronal responses in subjects viewing relatively affective (using suspense, drama, humour, etc.) and cognitive (based on plain facts) TV advertisements (Ioannides *et al.* 2000). The brain data suggest that cognitive advertisements activate predominantly posterior parietal and superior prefrontal cortices, whereas affective material modulates activity in orbitofrontal cortices, the amygdala and the brainstem. The results may imply that cognitive rather than affective advertisements activate cortical centres associated with the executive control of working memory and maintenance of higher-order representations of complex visual material. While differences between 'affective' and 'cognitive' ads were interesting, the activated brain areas did not correspond with the posterior frontal cortex or the ventromedial prefrontal cortex implied by Damasio's (1994) work on decision making.

An fMRI study found that the attractiveness of 30 pre-selected and classified print advertisements could be correlated with changes in brain activity in the nucleus accumbens, posterior cingulate, medial prefrontal cortex, higher-order visual cortices and in the fusiform face area (Kenning *et al.* 2006). The results could be interpreted as an interaction between the experienced attractiveness of an advertisement and facial expressions of persons displayed in the advertisement. Furthermore, it was found that ad attractiveness correlated with better ad recall. Interestingly, very unattractive ads were nearly as often recalled as very attractive ads. Unattractive ads could be correlated with changes in brain activity in the anterior insula, which was found to be involved in negative emotion processing (Greene *et al.* 2001). These findings suggest that the use of faces with a positive impression are perceived as attractive and advertisements using text-based information and faces with an affectively neutral expression are perceived as unattractive. Both had a higher recall than advertisements with an 'ambiguous' attractiveness. However, further research is needed to disentangle the linkages between faces used in advertisements and recall of the respective advertised brand to ensure that the effects found in the study are not solely due to effects induced by different emotional face expressions. In addition, it would be useful to integrate brand familiarity and knowledge of the advertised brands in the design employed in this study.

Ambler and Burne (1999) sought to explain the findings above with the 'Memory-Affect-Cognition' (MAC) theory. Under MAC, the great majority of decisions are low level or habitual and require no affective or cognitive engagement (i.e. M only). Following Damasio (1994), most other decisions involve memory and emotion only (i.e. M + A). Cognition, or cogitation, is used primarily for post-decision rationalisation. Finally, in some decisions – for example, where a group requires analysis and debate before the choice is made – cognition is involved (i.e. M + A + C).

The authors hypothesised a positive relation between affective ad content and higher recognition and recall. They found that a group of subjects treated with Propranolol, a beta-blocker known to reduce affect, had lower recall and recognition of affectively positive advertisements than a control group that was treated with a placebo.

Taken together, much of the work discussed above provides evidence of a positive relationship between affective ad content and ad memory, but not necessarily brand memory. Although there is a great body of neuroscientific literature about different memory systems such as long-term vs working memory and implicit (skills, primed and conditioned memories) vs explicit (semantic and episodic) long-term memory (Squire 1992), about the role of emotion in memory (LaBar & Cabeza 2006) and about how new memories are formed and later retrieved (Lavenex & Amaral 2000), little is known about how brand-related memories induced by advertising exposure are stored in the different memory systems. Ad memories, brand memories from communications and brand memories from usage or brand experience are all part of brand equity and all, presumably, linked, but it would be good to know how close those linkages are. For example, does advertising directly change brand experience memory, as suggested by Braun (1999)?

## *How brand memories influence behaviour*

Studies investigating the neural correlates of brand preference provide first evidence that emotional and self-referential memory structures play a crucial role within brand equity (Paulus & Frank 2003; Deppe *et al.* 2005a, 2005b). In a key study, Braun (1999) showed that ads can enhance the memory of brand experience, thereby making it more likely that the brand will be purchased at the next opportunity.

Daimler-Chrysler used MRI to investigate reactions to different types of cars (Erk *et al.* 2002). The researchers found a significantly greater activation in the brain's reward circuits (e.g. ventral striatum and orbitofrontal cortex, and anterior cingulate) when looking at sports cars (symbols of social status) than sedans or small cars. However, the authors did not record behavioural responses, making it difficult to assess what the reward-related activity might actually amount to in a possible buying situation. According to Addison (2005), other marketing companies that have explored these techniques include Delta Airlines, General Motors, Hallmark, Home Depot, Motorola and Procter & Gamble, but the results have not been made public.

Widespread attention has been given to a comparison of colas in an fMRI study by McClure *et al.* (2004). When tasted blind, Pepsi was preferred to Coke, as was widely publicised at the time of the New Coke disaster. In brain scanning the ventromedial prefrontal cortex, already noted as an emotion-processing area of the brain, was more activated for Pepsi, presumably because it is sweeter. When brand names were given, the subjects preferred Coke and activation in the ventromedial prefrontal cortex increased while tasting the preferred brand. When the subject was given the brand information about only one of the drinks (e.g. that one of the two drinks is Coke and the one other could be either Coke or Pepsi), increased neural activations were found during the brand-cued drink delivery of Coke in the hippocampus, dorsolateral prefrontal cortex and midbrain structures. These areas have previously been found to be involved in modifying behaviour based on memory and affect. These findings may suggest that a higher brand familiarity, induced, for example, by advertising, influences emotional memory structures that are associated with the respective brand and determines brand preference.

Other fMRI studies have investigated the impact of brand name information on preference judgment and product perception (Paulus & Frank 2003; Deppe *et al.* 2005a). Paulus and Frank (2003) examined whether neural correlates thought to be critical for emotional memories are involved in preference judgments between different soft drink brands. They found significant increased activation patterns in the ventromedial prefrontal cortex during preference judgment trials, as compared with visual discrimination trials. These findings suggest that brand name information may act as an emotional-memory-based somatic marker during preferences judgments.

Similarly, Deppe *et al.* (2005a) investigated the influence of a test person's first-choice brand as compared to other, diverse brands during preference judgments. They found that when the subject's first-choice beer/coffee brand was available, the ventromedial prefrontal cortex and other parts of the medial frontal cortex showed increased neural activation in contrast to when the first-choice brand was absent. Furthermore, in another study, it was revealed that this activation pattern is particularly involved when the consumption decision is characterised by higher uncertainty as compared to lower uncertainty (Plassmann *et al.* 2006).

Also in the context of brands, MEG was used to measure the neuronal correlates of decision making at the point of purchase (Ambler *et al.* 2004; Braeutigam *et al.* 2004). The data obtained from subjects selecting products on a virtual (video) supermarket visit suggest that such choice processes can be seen as two distinct halves. The first half appears to involve processes associated with problem recognition and memory recall, and here female brain responses differ most clearly from male. The second period concerns the choice itself, where a different pattern of brain activity is evoked when a relatively familiar brand is chosen compared with selecting a less well-known product. Choosing familiar items is associated with activation of right parietal cortices, indicating outcomes consistent with some form of intention based on previous experience. Ambler *et al.* (2004) speculated that the right parietal cortex may be associated with brand equity.

Selecting less well-known products is associated with activity in left inferior frontal (silent vocalisation) and right orbitofrontal (evaluation of reward values) cortices, as well as increased synchronisation in right dorsolateral cortices (consideration of multiple sources of information), indicating choices that are difficult in some sense. These MEG findings suggest that even repetitive and apparently simple day-to-day shopping choices rely on far from simple neural mechanisms. Interestingly, brain regions typically associated with the processing of reward value were particularly activated by less familiar grocery items.

Based on the general findings mentioned above, several studies were conducted to investigate more specific brand-related constructs such as brand loyalty, brand personality and also individual differences in brand perception.

In an fMRI study investigating the neural foundation of brand loyalty (Plassmann *et al.* in press), loyal and less loyal customers of a department store were imaged while making choices between two out of four department stores where they would buy different types of clothing. The experimental paradigm was designed to investigate systematic differences of neural processing during purchase decisions in the presence or absence of the specific target department store (the department store from which the subject pool was extracted) in contrast to three other department stores. The results showed that, for loyal customers, the presence of the specific store brand acts as a rewarding signal during the choice task, whereas disloyal customers do not reveal such a rewarding activation pattern. Furthermore, in line with the findings about the neural foundations of brand preference mentioned above, greater activation in areas of emotional and self-referencing memory retrieval was found. These findings allow the interpretation that loyal customers as compared with disloyal customers have established affective bonds to the store, which might be the most important underlying psychological driver of their repurchases. However, the directions of causality need to be targeted more specifically in future studies.

These findings align partly with findings reported by Schäfer *et al.* (2005). The aim of their fMRI study was to examine the neural correlates of culturally based brands. They instructed 13 subjects (2 males/ 11 females) to imagine driving a car manufactured by a culturally-familiar make, such as BMW. As a control condition, they used graphically comparable logos of car manufacturers that were unfamiliar to the culture of the subjects participating in this study. If the brand logo was unknown to the subjects, they were instructed to imagine driving a car in general, instead of imagining driving a specific make. Results showed activation of a single region in the medial prefrontal cortex related to the logos of the culturally familiar brands. More specifically, this region was the superior or medial frontal gyrus (Brodmann Area 8/9), which is known to be associated with self-reflection and self-relevant processing.

Yoon *et al.* (2006) investigated whether brand information is processed in brain areas involved in processing information about persons as compared with objects. fMRI indicated that correlates of brand and person judgments are processed in distinct neural networks. They found that judgments about brands from different product classes are processed in those brain areas that are involved in semantic object processing, rather than areas that are involved in judgments about people. Furthermore, they found that congruency between the participant's self-concept and brand associations does not moderate neural activation patterns. These findings shed light on the psychological states underlying brand choice and suggest that personality theory cannot be applied to brand theory. Interestingly, this study found neural activation patterns that differ from those mentioned in the studies above. These differences may be due to the comparison between brand names from a variety of different product categories with pictures of persons, whereas in the other studies pictures or the taste of brands from the same product category were compared to each other. Thus, future studies are needed to disentangle these differences – for example, by comparing brand with object judgments.

Finally, individual differences with respect to the influence of brand information on choice were targeted by another series of experiments by Deppe *et al.* (2005b). In these studies, subjects were asked to judge the credibility of 30 normalised (ten credible, ten ambiguous and ten not credible) news headlines by forced answers ('true', 'false'). Each headline was slightly semantically modified four times and was presented in four different magazine brand frames. The authors could show that the brand frame was influencing the credibility judgment when the news headline was ambiguous, which was found to be correlated with increased neural activations in the ventromedial prefrontal cortex. Furthermore, they found that this influence correlates with the degree of the subject's individual suggestibility. The latter was assessed via personality scales. These findings may indicate that the way advertising affects brand equity depends on individual differences such as personality traits. Further research is needed to understand the interaction between brand perception and the consumer's personality.

## What do we know so far and where does that lead us?

Taken together, these findings suggest that at least some aspects of advertisement perception, brand memory and economically relevant choice behaviour are amenable to neuroscientific investigation. In particular, distinct neuronal pathways emerge underlying ad recognition, ad recall, choice making and, therefore, brand equity. From a practitioner's perspective, however, the current research is a patchwork of largely unrelated studies addressing a wide range of potentially relevant issues. It appears that, to date, no direct 'recipes' can be derived from this new research. Yet the neuroscientific approach to advertisement research is exciting as well as promising.

## *Associative brand memories*

One area of research is whether advertising can change one's experiential brand memories, similar to so-called 'associative memory illusions' (Schacter *et al.* 1998; Park *et al.* 2005), as suggested by Braun (1999). Do ads change the memory of past brand consumptions? And/or does that memory of past brand experience shape the way later advertising is processed? It is conceivable that such questions can be addressed using an event-related response known as the N400 and detected by the EEG and MEG. This response is highly sensitive to processes of contextual integration, reflecting reliably the extent to which an individual stimulus is expected on the basis of information provided by the local context or retrieved from long-term memory (Kutas & Federmeier 2000). Thus, it might prove possible to obtain objective markers of, for example, the degree of expectation of brands and the mental association of brand attributes communicated in advertising for the respective brand, such as colour, shape, logo or name and other specific brand memories. More generally, neurophysiological markers could improve on methods to measure brand image, traditionally assessed by means of self-reports and hampered by subconscious associations and other factors that are difficult to observe behaviourally (see also Gontijo *et al.* 2002).

This strand could be broadened to address a long-standing debate in advertising research as to whether ads persuade people to change behaviour or merely reinforce existing behaviour (e.g. Ehrenberg 1974). Quite obviously some ads do more of one and some more of the other. What we do not know, but would like to, is how the two mechanisms work. Presumably the latter reinforce, or 'warm up', existing memories, possibly along the lines Braun (1999) suggested, whereas persuasion has the more difficult path of creating new memories or connections. This might be addressed with the help of measures of the synchronisation of brain activity (EEG, MEG, fMRI). Such measures have been employed in a variety of cognitive studies and could inform about the complex memory processes likely to be involved in the connection between advertising inputs and behaviour (synchronisation in the context of shopping choice was first studied in Braeutigam *et al.* 2004).

### *Emotion and the effect of advertisements*

The role of emotion in mental processes is a matter of intense debate, where Damasio (1994) argues for a strong, but not exclusive, role for emotion within an integrated nervous system in general. In particular, the research reviewed above confirms that ads successfully appealing to the emotions are better remembered than their 'cognitive cousins', although very little is known about the mechanisms supporting the formation of emotional memories and their effects on consumer choices. Here, the extensive research into the functional neuroanatomy of emotional memory that already exists (e.g. Dolan 2002; LaBar & Cabeza 2006) could be utilised to better understand the significance of neural activity elicited by a putatively affective ad and by a choice-inducing situation based on a product featured in the ad. Such insight might help to assess whether the ad has made a positive and lasting contribution to brand memories (brand equity).

What we now know about the areas of the brain involved in decision making makes it clear that it is not as simple as a cursory reading of Damasio (1994) would imply – namely, that we should focus on the ventromedial prefrontal cortex. However, Damasio is not necessarily wrong. In the first place a link is not necessarily a terminal: just because the ventromedial prefrontal cortex is activated does not mean that the relevant memories are located there. At the same time, if the link is broken, they cannot be accessed. The main studies so far are Ambler *et al.* (2004), McClure *et al.* (2004) and Deppe *et al.* (2005), but they are not wholly consistent.

Taken together, all these neuroscientific studies imply that brands act as rewards and their value relies on the interaction between memory and affect. However, we do not know psychologically how brand equity is established over time and the role played by advertising. We can surmise it is important, if only from the amount spent on it, and that it must interact with brand memories from earlier purchasing, consumption and other forms of communication (e.g. word of mouth).

Nevertheless, when we put all this together, it seems likely that building brand equity might follow the same neural principles as learning in general. In particular, we need to see if and how brand preferences are strengthened by ad reception, and vice versa.

### *Complexity of consumer choice processes*

A controversy exists about the overall mental involvement in consumer decision making. According to some models, those choices can be simple or habitual and without rational engagement (thinking) (MAC, Ambler & Burne 1999). Other models see choice making as a highly conditional form of complex information processing, sensitive to factors such as perceived justification, anticipated regret, time pressure, self-esteem and framing (Slovic 1995; Bettman *et al.* 1998). Part of the difference may be explained by the type of decision being made – for example, a brand of washing powder versus a new car – and whether the choice is being made by an individual or a group of people (family). This 'it depends' is consistent with the findings obtained by Braeutigam *et al.* (2004). Here, where a known brand was available the choice process appeared easier than when a choice from a set of wholly unfamiliar brands was involved. Specifically, multimodal neuroimaging (EEG or MEG + fMRI) could elucidate the neuronal networks involved in choice making, which could in turn yield a better understanding of what is required to map brand memories into brand choices.

### *What else needs exploration?*

Over and above event-related responses, measures of the synchronisation of brain activity could allow one to distinguish, dependent on a given context, between 'persuasive hierarchy' and 'reinforcement' models of advertising. The former see advertisements as providing information and reasons to buy and/or prefer the products advertised, assuming sequential mental processing according to learn first then feel and finally do. In contrast, reinforcement models view advertising as part of a continuing process where preferences are shaped, altered or reinforced by experience as well as communications, in line with recent assumptions according to which emotion plays an integral part in cognitive processes (Damasio 1998).

The tentative finding in Ambler *et al.* (2004) identifying part of the location of brand equity needs testing and development. Brain location, as an issue, can be overplayed but it is helpful to infer possible brain functions with locations especially, as in this case, when we are seeking to link the effects of advertising inputs with behavioural outputs.

Once we have a better understanding of whether and how advertising can add to brand equity, the contribution of different components of advertising to brand memories may be analysed in greater detail. For example, behavioural studies conducted by Armel and Rangel (2005) could show that exposure duration to different branded food products significantly interacts with rewarding or aversive values attributed to the specific product and also impacts subsequent choice behaviour. The longer subjects were exposed to pictures of 'positive' products, the higher was their decision value and the higher the subsequent choice probability. However, contrary to traditional mere exposure effects, the longer the subjects were exposed to pictures of disliked products the lower the decision value and choice probability. Future neuroscientific studies may target the question of whether the duration of advertising exposure plays a crucial role for the magnitude and valence of brand memories.

## Limitations

Although brain imaging techniques have great promise for advertising research, they also face the following limitations.

- To date, brain imaging has taken place in rather medical and technical environments, employing rather simple experimental designs. This is unrealistic in marketing terms and may bias the results.
- The complexity of the underlying neurophysiological processes necessitates a deep understanding of the specific neuroscientific technique to test possibilities – for example, the correct specification of respective control conditions.

- There are issues related to the public as well professional understanding of the interface between neuroscience and marketing research. For example, the media may induce a 'Big Brother' reaction to using science in this way to research advertising and marketing.
- Conversely, advertisers and the public might ignore neurobiological and technical restrictions and treat initial results as indisputable truth (MacKlem 2005; Mucha 2005). Thus, careful discussion of results is crucial to avoid possible misuse of brain imaging techniques in advertising research.

## Conclusions

The application of neuroscience to advertising issues has been widely hyped as well as criticised, sometimes under the titles of neuromarketing and neuroeconomics (see Lee *et al.* (in press) for a broad discussion of these approaches), but as yet few results have appeared in the literature. We began with Weilbacher's (2003) observation that practitioners preferred old myths to new understanding. Some prefer to believe that advertising directly persuades people to buy, and therefore advertising performance can be measured by sales, despite the logic to the effect that advertising, when it works at all, works by changing customer-based brand equity, which may affect behaviour but at a later date. Neuroscientists and advertisers need to work together so that research investigates how ads are processed, how the changed memories are stored and the subsequent changes in behaviour relative to the aspirations of the advertisers. In other words, they need to understand how brand equity is changed and how brand equity influences behaviour.

## References

Aaker, D.A. (1991) *Managing Brand Equity*. New York: The Free Press.
Aaker, D.A. (1996) *Building Strong Brands*. New York: The Free Press.
Addison, T. (2005) More science: more sense, or nonsense. *Admap*, **461** (May), pp. 24–27.
Ambler, T. & Burne, T. (1999) The impact of affect on the memory of advertising. *Journal of Advertising Research*, **39**(2), pp. 25–34.
Ambler, T., Braeutigam, S., Stins, J., Rose, S.P.R. & Swithenby, S.J. (2004) Salience and choice: neural correlates of shopping decisions. *Psychology & Marketing*, **21**, pp. 247–261.

Armel, K.C. & Rangel, A. (2005) Attention duration and the computation of decision values in simple choice. Society for Neuroeconomics Annual Meeting, Kiawah Island: Society for Neuroeconomics.

Baillet, S., Mosher, J.C. & Leahy, R.M. (2001) Electromagnetic brain mapping. *IEE Signal Processing Magazine*, **18**(6), pp. 14–30.

Bechara, A. & Damasio, A.R. (2005) The somatic marker hypothesis: a neural theory of economic decision. *Games and Economic Behavior*, **52**(2), pp. 336–372.

Bettman, J.R., Luce, M.F. & Payne, J.W. (1998) Constructive consumer choice processes. *Journal of Consumer Research*, **25**, 3 December, pp. 187–217.

Braeutigam, S., Rose, S.P.R., Swithenby, S.J. & 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. *European Journal of Neuroscience*, **20**, pp. 293–302.

Braun, K.A. (1999) Postexperience advertising effects on consumer memory. *Journal of Consumer Research*, **25**(3), pp. 319–334.

Crites Jr, S.L. & Aikman-Eckenrode, S.N. (2001) Making inferences concerning physiological responses: a reply to Rossiter, Silberstein, Harris and Nield. *Journal of Advertising Research*, **41**(2), pp. 23–26.

Damasio, A.R. (1994) *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Putnam.

Damasio, A.R. (1998) Emotion in the perspective of an integrated nervous system. *Brain Research Reviews*, **26**, pp. 83–86.

Deppe, M., Schwindt, W., Kugel, H., Plassmann, H. & Kenning, P. (2005a) Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision making. *Journal of Neuroimaging*, **15**(2), pp. 171–182.

Deppe, M., Schwindt, W., Kraemer, J., Kugel, H., Plassmann, H., Kenning, P. & Ringelstein, E. (2005b) Evidence for a neural correlate of a framing effect: bias-specific activity in the ventromedial prefrontal cortex during credibility judgments. *Brain Research Bulletin*, **67**(5), pp. 413–421.

Dolan, R.J. (2002) Emotion, cognition, and behavior. *Science*, **298**, pp. 1191–1194.

Ehrenberg, A.S.C. (1974) Repetitive advertising and the consumer. *Journal of Advertising Research*, **14**, 2 April, pp. 25–34.

Erk, S., Kiefer, M., Grothe, J., Wunderlich, A.P., Spitzer, M. & Walter, H. (2003) Emotional context modulates subsequent memory effect. *Neuroimage,* **18**, pp. 439–447.

Erk, S., Spitzer, M., Wunderlich, A.P., Galley, L. & Walter, H. (2002) Cultural objects modulate reward circuitry. *Neuroreport*, **13**(18), pp. 2499–2503.

Gontijo, P.F., Rayman, J., Zhang, S. & Zaidel, E. (2002) How brand names are special: brands, words, and hemispheres. *Brain and Language*, **82**, pp. 327–343.

Greene, J.D., Sommerville, R.B., Nystrom, L.E., Darley, J.M. & Cohen, J.D. (2001) An fMRI investigation of emotional engagement in moral judgment. *Science*, **293**(5537), pp. 2105–2108.

Huesing, B., Jäncke, L. & Tag, B. (2006) *Impact Assessment of Neuroimaging*. Zurich: vdf Hochschulverlag.

Ioannides, A.A., Liu, L., Theofilou, D., Dammers, J., Burne, T., Ambler, T. & Rose, S.P.R. (2000) Real time processing of affective and cognitive stimuli in the human brain extracted from MEG signals. *Brain Topography*, **13**, pp. 11–19.

Kandel, E.R., Schwartz, J.H. & Jessel, T.M. (eds) (2000) *Principles of Neural Science*. New York: McGraw-Hill.

Keller, K.L. (1993) Conceptualizing, measuring, and managing customer-based brand equity. *Journal of Marketing*, **57**(1), pp. 1–22.

Keller, K.L. (1998) *Strategic Brand Management*. Upper Saddle River, NJ: Prentice Hall.

Keller, K.L. & Lehmann, D. (2003) How do brands create value? *Marketing Management*, July/August, pp. 15–19.

Kemp, A.H., Gray, M.A., Eide, P., Silberstein, R.B. & Nathan, P.J. (2002) Steady-state visually evoked potential topography during processing of emotional valence in healthy subjects. *Neuroimage*, **17**, 4 December, pp. 1684–1692.

Kenning, P., Plassmann, H., Pieper, A., Schwindt, W., Kugel, H. & Deppe, M. (2006) Neural correlates of attractive ads. Working paper. Muenster.

Kutas, M. & Federmeier, K.M. (2000) Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Sciences*, **4**, pp. 463–470.

Kwong, K.K., Belliveau, J.W., Chesler, D.A., Goldberg, I.E., Weisskoff, R.M., Poncelet, B.P., Kennedy, D.N., Hoppel, B.E., Cohen, M.S., Turner, R., Cheng, H.-M., Brady, T.J. & Rosen, B.R. (1992) Dynamic magnetic resonance imaging of human brain activity during primary sensory stimulation. *Proceedings of the National Academy of Sciences of the United States of America*, **89**(12), pp. 5675–5679.

LaBar, K.S. & Cabeza, R. (2006) Cognitive neuroscience of emotional memory. Nature reviews. *Neuroscience*, **7**(1), pp. 54–64.

Lavenex, P. & Amaral, D.G. (2000) Hippocampal–neocortical interaction: a hierarchy of associativity. *Hippocampus*, **10**(4), pp. 420–430.

Lee, N., Broderick, A.J. & Chamberlain, L. (in press) What is ‘neuromarketing’? A discussion and agenda for future research. *International Journal of Psychophysiology*.

Lopez da Silva, F.H. & van Leeuwen, S.W. (eds) (1987) *Clinical Applications of Computer Analysis of EEG and Other Neurophysiological Signals*. London: Elsevier Science.

MacKlem, K. (2005) It’s mind over money. *Maclean’s*, **118**(23), 21 May, pp. 66–67.

Malmivuo, J. & Plonsey, R. (1995) *Bioelectromagnetism – Principles and Applications of Bioelectric and Biomagnetic Fields*. New York: Oxford University Press.

McClure, S.M., Li, J., Tomlin, D., Cypert, K.S., Montague, L. & Montague, P.R. (2004) Neural correlates of behavioral preference for culturally familiar drinks. *Neuron*, **44**(11), pp. 379–387.

Mucha, T. (2005) This is your brain on advertising. *Business 2.0*, **6**, 7 August, p. 35.

Noll, D.C. (2002) A Primer on MRI and fMRI, at www.eecs.umich.edu/~dnoll/primer2.pdf.

Ogawa, S., Tank, D.W., Menon, R., Ellermann, J.M., Kim, S.G., Merkle, H. & Ugurbil, K. (1992) Intrinsic signal changes accompanying sensory stimulation: functional brain mapping with magnetic resonance imaging. *Proceedings of the National Academy of Science of the USA*, **22**(1), pp. 210–216.

Park, L., Shobe, K.K. & Kihlstrom, J.F. (2005) Associative and categorical relations in the associative memory illusion. *Psychological Science*, **16**(10), pp. 792–797.
Paulus, M.P. & Frank, L.R. (2003) Ventromedial prefrontal cortex activation is critical for preference judgments. *Neuroreport*, **14**(10), pp. 1311–1315.
Plassmann, H., Kenning, P. & Ahlert, D. (2006) Neural correlates of brand choice under uncertainty: the role of brand trust. Society for Consumer Psychology Conference 2006 Proceedings, pp. 63–75.
Plassmann, H., Kenning, P. & Ahlert, D. (in press) Why companies should make their customers happy: the neural correlates of customer loyalty. *Advances in Consumer Research*.
Rossiter, J.R., Silberstein, R.B., Harris, P.G. & Nield, G. (2001) Brain-imaging detection of visual scene encoding in long-term memory for TV commercials. *Journal of Advertising Research*, **41**(2), March/April, pp. 13–21.
Roy, C.S. & Sherrington, C.S. (1890) On the regulation of the blood-supply of the brain. *Journal of Physiology*, **11**, pp. 85–108.
Sato, S. (ed.) (1990) *Magnetoencephalography. Advances in Neurology*, *54*. New York: Raven Press.
Schacter, D.L., Norman, K.A. & Koutstaal, W. (1998) The cognitive neuroscience of constructive memory. *Annual Review of Psychology*, **49**, pp. 289–318.
Schäfer, M., Berens, H., Heinze, H.J. & Rotte, M. (2005) Neural correlates of culturally familiar brands of car manufacturers. *NeuroImage*, **40**, pp. 322–327.
Silberstein, R.B., Harris, P.G., Nield, G.A. & Pipingas, A. (2000) Frontal steady-state potential changes predict long-term recognition memory performance. *International Journal of Psychophysiology*, **39**, pp. 79–85.
Slovic, P. (1995) The construction of preference. *American Psychologist*, **50**, pp. 364–371.
Squire, L.R. (1992) Memory and the hippocampus: a synthesis from findings with rats, monkeys, and humans. *Psychological Review*, **99**(2), pp. 195–231.
Thompson, R.F. (1993) *The Brain: A Neuroscience Primer*, 2nd edn (series eds Atkinson, R.C., Lindzey, G. & Thompson, R.F.). New York: W.H. Freeman and Company.
Weilbacher, W.M. (2003) Point of view: how advertising affects consumers. *Journal of Advertising Research*, **43**(2), pp. 230–234.
Yoon, C., Gutchess, A.H., Feinberg, F. & Polk, T.A. (2006) A functional magnetic resonance imaging study of neural dissociations between brand and person judgments. *Journal of Consumer Research*, **33**, 1 June, pp. 31–40.
Young, C. (2002) Brain waves, picture sorts, and branding moments. *Journal of Advertising Research*, **42**(4), July/August, pp. 42–53.

## About the authors

Hilke Plassmann is a Postdoctoral Researcher at the California Institute of Technology, US, where she has been since July 2006. Before that, she was a Postdoctoral Researcher at Stanford University, US. She received a PhD (Marketing and Neuroscience) from the University of Muenster's School of Business and Economics, Germany, in 2005 and a joint MBA equivalent from Muenster School of Business and Economics, Germany, and Montpellier Graduate School of Management, France, in 2001.

Her primary research areas are consumer decision making, consumer welfare and self-control, and brand management. Her work has been published in various marketing and neuroscience journals focusing on behavioural decision research.

Tim Ambler is a Senior Fellow at London Business School. His books include *Marketing and the Bottom Line* (2000, 2003), *Doing Business in China* (2000, 2003), *The SILK Road to International Marketing* (2000) and *Marketing from Advertising to Zen* (1996). He has published in the *Journal of Marketing*, *Journal of Marketing Research*, *International Journal of Research in Marketing*, *Psychology & Marketing*, *Journal of Advertising Research* and *International Journal of Advertising*. He was previously Joint Managing Director of International Distillers and Vintners, now part of Diageo plc, and involved in the launch of Baileys, Malibu and Archers, and the development of Smirnoff vodka worldwide.

Dr Sven Braeutigam is a research physicist at the University of Oxford. He received an MSc in Physics from the University of Hamburg, Germany, and a PhD in Neuroscience from the Open University, England. His research interests focus on the neural basis of cognitive processes such as the recognition of faces and decision making in economically relevant situations using magnetoencephalography as the main investigative tool. His teaching interests include neuroscience, MEG technology and software engineering. He has authored and co-authored academic papers in both neuroscience and marketing journals, and has made contributions to international conferences in these fields. He is a visiting research fellow at the Open University, functional imaging group, and a founding member of the society for neuroeconomics at the University of Muenster.

Dr Peter Kenning is associate professor at the Marketing Centre of the Westfalian Wilhelms-University of Muenster. His overall research interest is consumer behaviour, neuroeconomics and advertising research. His work has been published in marketing as well as in neuroscience journals, including *Advances in Consumer Research*, *Management Decisions*, *Journal of Neuroimaging* and *Brain Research Bulletin*. He has received several best-paper awards and grants from the German Government, and has been an fMRI visiting fellow at Harvard University.

Address correspondence to: Hilke Plassmann, Division of the Humanities and Social Sciences, California Institute of Technology, MC 228-77, 1200 E California Boulevard, Pasadena, CA, 91125, US
Email: hilke_plassmann@hss.caltech.edu