

Saliency and Choice: Neural correlates of shopping decisions

Tim Ambler, John Stins, Sven Braeutigam, Steven Rose, Stephen Swithenby¹

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Tim Ambler is Senior Fellow at London Business School

London Business School, Regent's Park, London NW1 4SA, U.K.

Tel: +44 (0)20 7262-5050 Fax: +44 (0)20 7724-1145

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¹ The first named is the corresponding author and is at London Business School, Regent's Park, London NW1 4SA, email tambler@london.edu. The other authors are at the Open University, Milton Keynes. We are very grateful to the four companies who sponsored this research, the subjects, who gave up much time and endured some discomfort to take part, and Brain Research Unit, Low Temperature Laboratory, Helsinki University of Technology.

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Abstract

Marketers are fundamentally interested in how consumers make buying decisions. A recent method of non-invasive brain imaging, magnetoencephalography (MEG), was used to observe subjects making decisions on a virtual (video) supermarket visit. At each of 90 stops, the subject was invited to choose one of three brands. Package height and color discrimination tests provided control experiments. Subjects also completed a questionnaire to indicate their familiarity with each of the brands shown in the video. The objectives were to identify the brain regions that become differentially engaged when choosing brands, as against discriminating packaging height or color. As expected, activations in brand choice differed from those for height or color discrimination and were faster when one brand was more familiar. Brand choice appeared to involve silent vocalization. The right parietal cortex was only activated where the brand was salient, operationalized here as strong relative brand familiarity. This therefore appears to be a key location for brand equity both because it is only activated for the most salient brands and because it seems to be linked with intentionality. This is probably the first time any element of brand equity has been located in the brain. Some gender effects were found. The paper concludes with the benefits for marketers and marketing research. This research pioneers new techniques using relatively few subjects and against a limited theoretical background. As such it must be classified as exploratory.

Saliency and Choice: Neural correlates of shopping decisions

Marketers are fundamentally interested in how consumers make buying decisions and now we can virtually look into their minds when they are doing so. This paper reports research using a recent non-invasive brain imaging methodology, magnetoencephalography (MEG). This research is believed to be the first examination of brand choice using MEG and explores how brain activation for familiar brands, i.e. those with higher brand equity, differ from less familiar brands. For the purpose of this paper, saliency was operationalized as relative familiarity. The objective was to identify the brain regions that become differentially engaged when choosing to purchase a particular brand, as against simply responding to some feature of the packaging, and the extent to which brand saliency would affect both the choice and the associated brain processes. . This research pioneers new techniques using relatively few subjects and against a limited theoretical background. As such it must be classified as exploratory.

Decision-making has to reconcile new information arriving at the point of decision with existing mental representations, i.e. awareness, preference and experience in the case of brands. This research shifts the balance of attention from the new stimuli, which are most often the subject of research, to what consumers already have in their heads. While decision-making may involve both, some researchers (e.g. Ehrenberg, 1974; 1994) have long argued that advertising [persuasion] is less important than ingrained behavior, i.e. habitual memory. Whilst our research design does not permit us to explore the many possible cognitive or affective factors shaping a person's preference, we seek to identify at least some of the brain regions engaged.

The paper is structured as follows. A brief contextual section positions the paper within the wider framework of the role and measurement of brand equity and describes the technology. A review of previous work leads to the issues for research. The exploratory nature of this work is not strictly inductive, still less, in view of the paucity of theory, hypothetico-deductive. Nevertheless previous research, and logical consistency, indicated some areas of expectation. This is followed by the experimental design that approximates real decision-making, as subjects make a virtual tour of a supermarket and make consumer choices from items on display. Indeed, as an increasing number of people actually shop on the Internet, real life and this study situation come ever closer. Height and color discrimination form our two control tasks.

As with any technique in its infancy, limitations and reservations are plentiful but, at the risk of overstatement, the development can be compared with the early cinema. At this stage what we are seeing is far from clear but we do know it is a different way of perceiving the world. Psychology is becoming increasingly anchored in neuroscience and the future lies in integrating approaches derived from the two scientific fields.

Finally we draw some managerial implications and conclusions.

Context

Two types of context frame this research: our understanding of brand equity and the technology available for measuring, not so much our existing mental representations as the way we respond to stimuli.

We know that advertising works at least some of the time. Where there is an interval between the advertising and the opportunity to buy, i.e. the next supermarket visit, it follows that

the effects of the advertising must change our mental representations if they are later to influence choice. Brand equity is variously defined but the mainstream (see Keller, 1998, Figure 2-1, p.43) sees it as an asset that good marketing creates in minds of consumers and other stakeholders. Advertising has a role to play in forming our mental representations but it is more likely that, in general, they are based on brand usage experience. Thus customer-based brand equity is just that part of the total asset in the minds of customers. As a relatively new concept stemming from the 1980s, consensus on marketing assets may take time to be established but, for the purpose of this paper, we can take brand equity to be stored as memory broadly defined (Rose, 1993). The question here is whether any elements of brand equity, such as familiarity or salience, will be measurable when a purchase decision is being made.

The variety of measurement technologies now available provides ‘windows into the brain’ enabling regions actively engaged in some neural/behavioral process to be identified. Perhaps the best known are PET (positron emission tomography) and fMRI (functional magnetic resonance imaging). Both give very good spatial information but at the cost of having to average brain activity over periods of several seconds. This may not seem very long, but when the time taken to make a decision to purchase a familiar brand from a supermarket shelf may be complete within 2-3 seconds, and involve highly dynamic brain activity, such techniques are of limited value.

An alternative is magnetoencephalography (MEG), a method that depends on the fact that as neural signaling is electrical in character, and as electric currents cause magnetic fields, the brain and skull are surrounded by minute fluctuating magnetic fields. These can be measured by devices called SQUIDS (superconducting quantum interference devices) operating at the

temperature of liquid helium, and a small number of MEG facilities now exist world-wide. The merit of MEG is that it can identify dynamic brain processes occurring on a millisecond time scale, albeit with poorer spatial resolution than more conventional methods. (For an introduction to MEG, see Aine, 1995). The importance for marketing research lies in the prospect of using MEG to achieve real-time brain imaging of decision-making.

There is of course no suggestion that the brain has created any special area for brand equity: that would make no sense. But on the other hand brand memories have to be stored somewhere and we here explore what elements of brand equity appear to be activated during a supermarket brand purchase decision.

Previous research

Holbrook, O'Shaughnessy and Bell (1990, p.137) integrated competing marketing schools of thought into "An Integrative Overview of the Consumption Experience" with three types of component: reasons (thoughts, intention), emotions (wants, appreciation) and memory (habit, reinforcement, experience). Usage reinforced the emotional components that, in turn, acted on rationality and habit which drove acquisition. At the same time, thoughts and wants, looped with emotions, also moderated reasons.

In this view, the emotions are drivers with habit and cognitive factors, whether from new stimuli or brand knowledge, in subsidiary roles. From quite a different research discipline, Damasio (1994) determined that decision-making was feelings-based, not solely rational. "Part of a region which our recent investigations have highlighted as critical for normal decision-making, the ventromedial prefrontal region," (p. 32) appeared to explain subjects' inability to

make decisions when it was damaged (the area is shown as “OB” in Figure 1). This is later emphasized as “A fourth reason why the prefrontal cortices are ideally suited for participating in reasoning and deciding is that they are directly connected to every avenue of motor and chemical response available to the brain.....Upstairs and downstairs come together harmoniously in the ventromedial prefrontal cortices” (p.183). His findings are supported by Adolphs et al. (1994) and Phelps and Anderson (1997).

Insert Figure 1 about here

The relative influence on decision-making by the cognitive, emotional and memory elements of our minds might accordingly be revealed by brain scanning the brains while shopping choices are being made. The emotional aspect is particularly interesting as it contrasts with the Cartesian, or rational optimizing, assumption often made about human behavior (e.g. Bettman, Luce & Payne, 1998). In the rational model, choice-making is explained by comparing the attributes of the alternative brands and then trading off those attributes according to their desirability, e.g. Bhargava, Kim and Srivastava (2000).

Bagozzi, Gopinath and Nyer (1999) reviewed the literature concerning the role of emotions in marketing. They suggested that recent research has given considerable attention to the way emotional reactions to ads influence consumer decision-making but this attention has

tended to focus more on the first part of this (the ads), e.g. Agres, Edell and Dubitsky (1990), Ambler and Burne (1999), than on decision-making. Their first proposal for future research was to examine how consumer appraisals are conducted and in particular the roles of the amygdala, hippocampus, and other neural systems. This paper is a step in that direction.

Luce, Bettman and Payne (2001) focused their attention on emotional decisions. To do so, they conceptualize consumer decision-making as trading off various product attributes. These are emotional to the extent that they have emotional consequences, i.e. the alternative outcomes are emotionally-charged. Undoubtedly their model is a valuable development of the decision literature but it proceeds from the assumption that decisions are a rational (cognitive) trade-off process that is being modified by coping with outcomes differentially laden with emotion. Thus, unlike the Damasio (1994) conclusion, they assume the process itself to be as rational as it can be.

Some researchers have noted that the balance between cognitive and emotional processing may be moderated by context and time availability in particular. Shiv and Fedorikhin (1999) showed that a shortage of time for decision-making skewed the balance toward the emotional. Dhar, Nowlis and Sherman (2000) examine the effect of time pressure on context effects which are themselves due to consumers seeking to minimize the effort involved in making choices.

Finally, gender has been found to have a moderating effect on choice making. For example, Fischer and Arnold (1990) found gender roles to be associated with involvement in Christmas shopping. Men with more feminine gender roles, like women, were more involved. Similarly, but to a lesser extent, gender identities were associated with greater involvement. Of

more relevance to this research, Adam et al. (1999), in a study of 12 male and 12 female participants, found men to have faster reaction times and surmised this may be due to differences in brain processing strategies. Herrmann and Crawford (1992) found that gender stereotypes correlated with memory tasks. Women were relatively more successful at memorizing shopping lists than geographical directions but when the contents of the shopping lists were adjusted in gender stereotypical ways, the effects diminished. For example, grocery shopping lists were more easily remembered by women but when the contents were switched to hardware items their recollection diminished. Furthermore, women are more likely to use shopping lists (Block & Morwitz, 1999). A more general review of gender effects has been provided by Fausto-Sterling (1992).

Issues for research

Against this background, we consider that the theory is not clear enough in neurological terms to test formal hypotheses. On the other hand, the issues for exploration were:

Broadly speaking, we expected easier decisions to be quicker. Firstly, as brand choice involves memory and emotional activation not required for a more simple discrimination task such as judging color and the relative heights of three packages (Gross, 1995), we expected that reaction times for brand choice will be longer than for visual discrimination (I1). Secondly, where one brand is more familiar than the others, the decision is likely to be faster than for equally familiar or unfamiliar brands (I2).

Activation of the left anterior and medial temporal cortices is known from a variety of brain imaging studies to be engaged in semantic processing and the memory-based interpretation of visually presented material (McCarthy, Nobre, Bentin & Spencer 1995; Braeutigam, Bailey & Swithenby 2001a; Damasio et al. 1996; Nyberg et al. 1996). If this MEG technique is to be useful in decision research, we would expect as a minimum for brain activation differences to be observed between brand choice and height discrimination when the same visual images are used (I3). The more interesting issue here is the variety of differences that may emerge.

Although the sample size is small, we expected to find some gender related differences in brain processing (I4).

And finally, in line with Damasio (1994) and Ambler, Ioannides and Rose (2000), we expected brand choice decisions to be associated with activations in the frontal lobe (e.g. OB in Figure 1) (I5). This was the only location clearly predicted by the literature but the research was, probably more importantly, directed broadly to look for any significant activation differences between brand choice and visual discrimination.

Experimental design

Following initial piloting, the design had four stages: a supermarket virtual tour to choose brands, a repeat of the tour in which subjects were merely asked as a control to choose the shortest from amongst the choice of brands they were presented with, followed by a color discrimination task, and, finally, the completion of a questionnaire to assess brand familiarity.

Eight participants (4 female, 4 male, age between 30 and 63) were presented with footage of the interior of a familiar supermarket in England, where all subjects had previous experience

of shopping, at least occasionally. All 8 subjects had previously participated in the pilot study. The footage comprised 18 scenes of walking along the aisles and shelves. Each scene showed a selection of common consumer items belonging to a certain brand category. The scenes cued subjects on the category of products that would be shown in 5 static images after each video scene. These images constituted the actual stimuli. There were a total of 90 (18 x 5) one-out-of-three choices to be made (90 x 3 = 270 items). The video lasted about 18 minutes. Participants were asked to indicate which of the 3 items they would purchase if given the choice by pressing with their index, middle, or ring finger corresponding to the left, middle or right item shown in the image. They were instructed to press with their thumb when they felt they could not make a choice. Subjects were asked to ignore price differentials, and were informed that they would be given a shopping voucher (GBP 50), which could be used to purchase products selected during the MEG experiment.

At the end of the experiments, participants filled out a questionnaire on which they used a five-point scale to indicate their familiarity with each of the 270 consumer items. For each subject, these questionnaire returns were used to calculate a measure S of the salience of a chosen item within the context of a given image according to

$$S = V_C - \frac{1}{2}(V_1 + V_2),$$

where the V_C represents the questionnaire score of the item chosen and V_1 and V_2 represent the scores of the non-chosen items. S ranges from -4 to 4 . The maximum is achieved if the item chosen (V_C) scores 5, whereas the two non-chosen items (V_1 and V_2) each score 1. Thus salience is a way of expressing the relative familiarity of the subject for one out of the three brands available for choice. The higher the salience, the stronger is the relative familiarity. For

subsequent analysis, data epochs from the choice task were median split into two groups according to decreasing values of S and the groups denoted by high and low respectively.

The brands covered 18 categories: jams and spreads, pet food, dairy products, beers, crisps, cereals, meat products, tinned food, teas and coffees, soft drinks, prepared meals, salad dressings, vegetables and fruits, rice and pasta, body care products, wines and liquors, table sauces, and detergents.

In the main control task, participants were presented with a random sequence of 60 images drawn from those used in the choice experiment. The task was to indicate which of the three items (left, middle, or right) was the shortest, again by pressing one of the respective keys (pressing with the thumb was possible if subjects felt they could not discriminate between the heights of the items). The presentation lasted for about 8 minutes. The use of 60 images was based on the pilot study, which had suggested a higher frequency of no-choice responses than actually occurred. In a further control (color discrimination), participants were presented with a random sequence of 60 images showing three geometrical objects arranged in a row. The task was to indicate which of the three objects (left, middle, or right) was red, again by pressing one of the respective keys. A small proportion of images did not feature an object in red, where subjects had to press with their thumbs. The experiment lasted about 8 minutes.

Neuromagnetic responses following image presentation were recorded using a VectorViewTM MEG system (Hämäläinen, 1997), which is based around a helmet-shaped array of 102 pairs of first order gradiometer sensors. The outputs of each pair of detectors are most sensitive to the tangential current flow in the region directly below the detectors (see Figure 2).

Figure 2 about here

For each subject, all epochs were averaged according to task and high-low salience conditions within the interval – 200 to 1000 ms ($t = 0$ denotes stimulus onset). This gives a total of 5 types of average evoked response for this study (choice, height, color, choice-low-salience, and choice-high-salience). Significant differences between pairs of evoked responses were sought using a time-dependent measure P (Braeutigam, Bailey & Swithenby, 2001b). It identifies latencies where, across the subject group as a whole, there are significant differences between the responses from two types of evoked response.

By itself, MEG analysis reveals patterns of neural activity mapped in signal space, which can colloquially be described a time-dependent set of magnetic fields generated by neurons of the three dimensional brain. To locate the sources of the signals observed to specific brain structures, it is necessary to project onto MRI images for each individual subject. Thus we complemented our time-series analysis by a source estimation procedure in four (male) subjects for which anatomical MRI scans were available. The cortical source components obtained in this way best describe the observed differences between signals. Based on the data available, an assessment of significance in source-space was not possible. Also, identification of possibly deep sources could not be achieved consistently.

The MEG analyses presented below relate to the first second following presentation of the stimuli. In the choice condition, subjects took an average of 2.6sec to confirm their decision by pressing a key, whilst in the control conditions they were considerably faster. We were thus

able to contrast choice and control conditions only for the initial stages of the response, before the motor activity associated with the key press in the control conditions confounded the data. By contrast, we were able to compare high and low salience responses within the choice task across the entire time frame. We expected to find differences in activation between choice and control conditions, and between high and low salience stimuli. We also anticipated that we would find a dynamic pattern of activation, with early signals being detected in the visual cortex, before those regions of the brain associated with memory processes (notably the inferior-temporal cortex) become engaged, and we analyzed our data in the context of these expectations.

Results

Brand familiarity and choice

For each of the 90 images in the video, subjects could choose one of the three items of the image set, or decline to choose. Overall there were 74 percent positive choices, a mean which masked individual differences – positive choices ranged from 56 - 96 percent between subjects. Familiarity as indicated by the questionnaire was a good predictor of choice. On the five point questionnaire scale, the average score of the chosen items was 2.9 and of the non-chosen 1.9 ($t(7):4.1, p<0.01$).

As a consequence, salience was biased towards its maximum (4). The set of high salience stimuli was dominated (90%) by trials in which the item chosen scored higher than either of the two non-chosen items. For the remaining 10% of trials in this set, the item chosen scored at least 2 points higher than one of the non-chosen items. In 70% of low salience trials, familiarity scores

were equal or nearly equal for the 3 items. In the remaining 30 percent of cases in the low salience set, the item chosen was less familiar than at least one of the other two.

A comparison between the pilot and actual study revealed an overall consistency of choice of 69 percent (out of 270 items). This consistency, while far from 100 percent was well in excess of random (33 percent even if “no choice” is discounted). The shortfall was mainly accounted for by low salience stimuli.

The number of non-choice key presses significantly anti-correlated with questionnaire scores across product categories ($\rho = -0.51$, $p < 0.05$). Despite this finding, the occurrence of non-choices was too varied across subjects to allow further behavioral or magnetoencephalographic analysis of these trials.

Despite the limitations imposed by the small number of subjects, analysis suggests that the distribution of salience across brand categories may be affected by the gender of the subject. The occurrence of high salience trials in categories 1 (jams and spreads) and 15 (body care products) was significantly higher ($p < 0.05$) for female subjects. There is some indication ($p < 0.1$) for a reverse effect in categories 9 (teas and coffees) and 16 (wine and liquors), where male subjects had a relatively higher rate of high salience trials.

Reaction times

Reaction times were defined as the time-span from onset of image to key-press. Subjects responded significantly ($p < 0.001$) faster to high salience stimuli (average key-press at 2415 ms²) than to low salience stimuli (2995 ms). Decision-making in the control tasks was much

² Millisecond

faster, and subjects responded by pressing the appropriate key on average 950 ms and 750 ms after stimulus onset, for height and color respectively. In the control conditions, the occurrence of ‘cannot discriminate’ presses was negligible (< 0.5 percent). Gender comparison suggested that the salience effect on reaction times is more pronounced in females than in males ($\Delta = 290$ ms; $p < 0.05$), and, as predicted by the literature noted above, that females responded slower in the height control task ($\Delta = 105$ ms; $p < 0.02$). While it was not possible fully to separate the gender from the salience effect on reaction times with a sample of this size, the results were consistent with the possibility of gender-moderated salience.

Neural activity

Evoked responses elicited by the choice condition exhibited a complex pattern in time and space across subjects. First appreciable evoked responses were observed over occipital primary-visual cortices at about 100 ms after presentation of the images. Consistent evoked responses followed at latencies up to about 200 ms over extra-striate and parietal regions for a given subject, but the responses varied between subjects. At longer latency, where inter-subject variability was greater, evoked activity is seen in rough sequence over anterior temporal, pre-frontal, frontal, occipital, and parietal areas during the period from 300 ms to about 1000 ms after stimulus onset (Figure 3 shows the overall time course of neural activity). At about 1100 ms evoked responses begin to decrease rapidly. The consistency of neural activity with respect to the inducing stimulus is lost, and the evoked responses become unsuitable for analysis.

Figure 3 about here

In both control tasks, evoked responses were observed broadly similar to the choice tasks for latencies up to about 300 ms. At around 400 ms, evoked activity decreased rapidly consistent with a variety of studies requiring the discrimination of (complex) visual stimuli. At longer latency (> 500 ms), evoked responses were associated with the motor activity required by the ensuing key presses. These responses were highly varied across subjects and without any (stimulus-locked) pattern.

Based on these observations, statistical analysis using the measure $P (< 0.01)$ identified four characteristic stages, where neural activity is modulated by either task condition or salience. Because of motor activity, comparisons between the choice and control tasks were restricted to 0 to 400 ms after stimulus onset. All effects are robust in signal-space, supported in at least six out of eight subjects (all four effects are present in five subjects), and statistically significant across the group of subjects. These stages form a ‘time-line’ of characteristic events depicted in Figure 4, and briefly described below (see Figure 1 for brain areas mentioned in text).

Figure 4 about here

Stage 1 – V (visual): Responses over primary visual cortices at around 90 ms after stimulus onset. This was consistent with a localized source in primary visual cortex. Signal amplitudes were highest in the choice task, second highest in the height control task, and weakest in the color control task. The differences between the evoked amplitudes elicited by the two control tasks are also significant. No evidence was found that this stage depends on salience.

Stage 2 –T (temporal): Neuronal activity over left temporal cortices at around 325 ms after stimulus onset, predominantly generated in left anterior temporal cortices, extending, to variable degree, to ventral and medial temporal areas. Some generators were also found in left middle frontal gyri, orbital gyri, and right right extra-striate cortex. Within this latency range, signal amplitudes following presentation of the images were higher when choosing an item as opposed to either determining the shortest item or the red item. No such effect was found when comparing the two control tasks. No evidence was found that this stage depends on salience.

Stage 3 –F (frontal): Responses over left inferior frontal cortices at around 510 ms after stimulus onset. Within this latency range, signal amplitudes following low-salience stimuli were higher than those following high-salience stimuli. The results of the source analysis suggest that this activity is predominantly generated in cortical regions homologous to Broca's speech area, together with some evidence for activation of secondary visual cortices.

Stage 4 – P (parietal): Responses over right parietal cortices at around 885 ms after stimulus onset. Within this latency range, signal amplitudes following high-salience stimuli were higher than those following low-salience stimuli. Source estimates suggest a strong contribution from right, posterior parietal cortices. At this latency, non-differential generators in secondary visual, extra-striate, and orbital regions are also involved to varying degrees across subjects.

The sample size was not sufficiently large to explore any gender differences that may exist in the neural processing of decisions.

Discussion

The behavioral responses of subjects in this simulated shopping environment suggest that they did indeed engage in higher order cognitive processes that might reasonably be linked to making purchasing decisions. Response times were much longer than would be expected for the two control tasks based on purely height or color discrimination, and the questionnaire responses correlated strongly with the choices made during the MEG recording sessions. Also, the pattern found for non-choices points to a plausible behavior in that the subjects did not choose when familiarity was low.

The salience measure that provides a comparative rating of the three consumer items in each image appears to be a useful indicator of buying behavior. If all three items are (nearly) equal in familiarity, even if the familiarity is strong, the salience is low. It seems reasonable to assume that low salience stimuli are those in which there may be some form of (perceived) ambiguity or perplexity in making a choice. The longer response times for low salience stimuli seem to reflect this putatively harder choice.

The magnetoencephalographic results averaged across all subjects revealed a robust temporal sequence of neural responses. This sequence decomposes into differential stages related to task condition and salience.

The timing of the initial primary visual response V was compatible with previous findings, but it was stronger in the choice than in the control conditions. One interpretation

would be that a complex stimulus has to be strongly represented in striate cortex for subsequent higher analysis, i.e. the early response to the brand picture is affected by the purposes intended for perception. This view would be in accordance with findings that a high working memory load in a task requiring visual selective attention is associated with increased activity in occipital cortices (de Fockert et al. 2001). However, in the first control task, requiring height discrimination of products, the signal amplitudes were also higher than in the color discrimination task based around abstract objects. Presumably, therefore, the strength of the cortical representation is related to both the complexity of the images and the demands of the task.

The later response **T** was also stronger in the consumer choice task. The effect is clearly induced by this task in that the responses following the height task do not differ from the responses obtained from the color task. The underlying generators are known from a variety of studies to be engaged in semantic processing and the memory-based interpretation of visually presented material (McCarthy et al. 1995; Braeutigam, Bailey & Swithenby 2001b; Damasio et al. 1996; Nyberg et al. 1996). Thus, these responses may relate to the images being recognized and compared with data recalled from memories of the relevant brands and products. Such memories are complex with episodic and, in many cases, affective and cognitive elements. The memories probably involve actual experience of purchasing, using or seeing advertisements for the specific brands. However, comparisons occurring at this latency seem to be of a rather general character as there is no dependence on the salience measure.

Differential responses **F** followed at around 510 ms mapping initially onto Broca's area. These responses might relate to silent vocalization occurring in interpreting visual presentations

(Tulving et al. 1996). Thus, the stronger signal from the low salience stimuli, where the subjects may face difficulty in making a decision, may indicate an increased tendency to vocalize as a strategy that aids decision-making in the absence of easily retrieved preference. It remains unclear what initiates such vocalization, as post-hoc scrutiny of images did not reveal a link to obvious features provided in the images, such as color, shape or linguistic (text) information. Also, it remains elusive whether this putative vocalization might be specifically affected by gender or brand category.

The time-line concludes with a characteristic response at 885 ms, generated in the right parietal cortex **P**. This response is largest in high salience conditions, where the subject has a strong familiarity with or preference for one of the three brands/products.

The parietal cortex is a large and complex region, parts of which are conventionally associated with the planning of motor activity. However as our subjects were right handed and pressing a keypad with their right fingers, which would be expected to engage left parietal activity, this cannot be the explanation. The parietal also receives converging input from many sources, making it available for second order mapping; it is engaged in relating spatial to other representations (Anderson & Zipser, 1990), notably during memory retrieval. Lesions of the right parietal affect a person's capacity to produce speech with normal prosody and emotion (Heilman, Scholes, & Watson, 1975; Ross & Mesulam, 1979).

Damasio has broadened these observations into a specific 'somatic marker hypothesis' according to which damage to the right parietal cortex (Damasio 2000; Charlton, 2000) results in anosognosia, i.e. intentionality is profoundly damaged. Thus such lesions prevent a person from being able to "decide advantageously in situations involving risk and conflict...[or] to resonate

emotionally” in such situations (p.41). Clearly the choice task with which our subjects were presented, where familiarity is strong, is likely to engage just those processes that are damaged by right parietal lesions.

A further, not necessarily alternative, explanation draws on the role of the right parietal cortex in selective and sustained attention processes (Cabeza & Nyberg, 1997; Vallar, 1997) as well as higher levels of motor control (Kandel, Schwartz & Jessel, 1991). Accordingly, right parietal activity may signify a (final) attentional focus on the item already chosen, in order to visually ‘hold’ it during ensuing or already initiated motor control necessary for the key-press. However, the key-press itself occurs more than 1.6 seconds after the right parietal activation, implying that this region is likely to be engaged in the conscious and emotionally charged processes of choosing and preparing to indicate the more familiar brand. Since this activation was less marked in the low salience condition, the alternative (attentional) explanation seems less likely.

In summary, we explored five research issues but also found three unexpected results. The first research issue concerned reaction times and, as expected, reaction times for brand choice were longer than for visual discrimination (I1). Secondly, the decision times were shorter for high-saliency brands (I2).

We did find brain activation differences between brand choice and height discrimination when the same visual images are used (I3). The three specific findings were not predicted and were the activation of Broca’s area in low-salience conditions, the right parietal cortex and the implied intentionality for purchase.

We found gender related differences in reaction times for brand choice and height discrimination but not for brain processing (I4). Although sample size prevents certainty, the indications were that the brand choice differences were not wholly explained by salience. Of course these differences imply that processing differences probably exist even though we did not detect them.

We did not find brand choice decisions to be associated with activations in the frontal lobe (e.g. OB in Figure 1 or orbital gyrus) (I5). Again this does not imply that this area is not involved in decision-making. For example, it could be a pathway for decisions without being significantly activated. That would be consistent with damage to the ventromedial prefrontal lobes inhibiting decision-making without being a terminus, so to speak, for the decision.

Limitations and future research

So far as we know, this is the first time MEG technology has been applied to buying decisions. As such the research must be regarded as exploratory. By the conventional standards of marketing research the sample size was small. That in turn prohibited our ability to rotate stimuli since we needed to compare like with like and to aggregate. We do not expect framing or sequence factors to affect these results but the possibility exists. When the opportunity next appears, it would be interesting to replicate this work with different sequencing to test the issue.

Similarly, a larger sample would allow researchers to probe gender effects on brain processing but we would not expect that to change the apparent absence of activation in the ventromedial prefrontal lobes. Other techniques would be required to explore that.

That question arose as part of the issue of the emotionality of decision-making. The Damasio (1994) thesis was that all these non-habitual decisions required feelings-based parts of the brain. More needs to be done to establish the relative importance of, and sequence of, emotional or feelings-related and cognitive activations.

Finally we have assumed that all these brands and categories are similar. Research is needed both to assess differences within supermarkets and brands and with other types of products, e.g. purchasing cars.

Conclusions

From the point of view of practitioners, we have demonstrated that brain imaging of decision-making is now possible. That brand choice engages the brain longer, and in more complex, ways than height discrimination is not surprising. More interesting is the way the brain appears to use vocalization actively in that choice process; we can hypothesize that this re-affirms the importance of brand names. Most important of all, as is discussed below, is the possible identification of a key area involved in final choice of a product or brand in comparison with others, a choice that is correlated with the subject's familiarity with that brand. There is relevance here to the theme of brand equity. Clearly neither the right parietal activity nor the associated brand salience explain all brand equity but they would appear to be part of it. It seems likely, from this research, that the right parietal region is activated in the integration of advertising and memory of brand/product experience with consumer choice takes place in. Linking these events through the advertising, experience and choice processes requires further research.

The neural mechanisms underlying such shopping behavior are complex. They may draw on the specificity of individuals' past experience and engage many interacting psychological and social processes not explored here with, doubtless, appropriate brain correlates. However, this study has provided some evidence that relevant behavioral measures of relative familiarity (salience) associated with consumer items may translate into differential neural activity at specific stages.

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Figure Captions

Figure 1: A) An experimental cycle used in the choice task. There were a total of 18 cycles, each of which comprised a video sequence of 20 seconds followed by 5 choice stimuli (I) displayed for 5 seconds followed by 3 second inter-stimulus-interval. B) Example stimuli used in the choice and height control tasks. C) Example stimuli used in the colour control task. All images had the same size on screen.

Figure 2: A) The helmet-shaped array of detectors. Each plate symbolises two orthogonal, first-order gradiometers most sensitive to directly underlying neural currents. B) Global root-mean-square-signal (arbitrary units) after the choice stimulus, summed over all subjects and channels. The curve shows at a glance the average wave-form elicited by all stimuli in all subjects. The solid line denotes the average reaction time (time required to make a choice; dotted line: reaction time minus 1 standard deviation).

Figure 3: Time-line of differential stages identified within the 1 second interval after stimulus presentation. There are 2 task induced stages, where the choice condition elicits stronger signals in primary visual and left temporal cortices respectively. At longer latency, there are 2 familiarity (salience) related stages, where low salience stimuli evoke stronger responses in left frontal cortices, and where high salience stimuli elicit stronger signals in right parietal cortices respectively.

Figure 4: Brain areas mentioned in the text.

Key:

OB/SF/MF - orbital/superior frontal/middle frontal gyrus are part of an extensive area known as the pre-frontal association cortex. It receives input from many cortical and sub-cortical areas, commonly assigned a regulatory role of a person's depth of feeling, initiative and judgement

OCC - occipital cortex, encompasses primary visual area, which receives input from the eyes

EXS - extra-striate cortex, second order processing of visual information, involved in shape, movement, and object recognition

IOT - inferior occipito-temporal cortex, similar to EXS, distinction is difficult

P- parietal cortex, complex sensory input (anterior parts), higher order integration, motor planning (posterior parts, these are also termed association cortices)

CB - cerebellum, control of posture, co-ordination of limb and eye movements

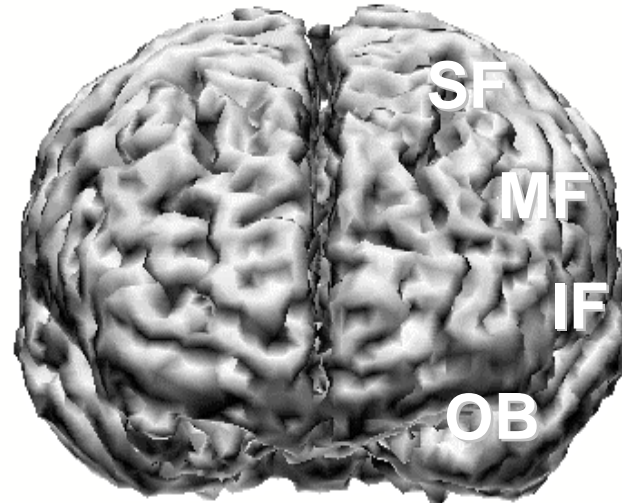
AT/MT - anterior/medial temporal cortices, memory recall, semantic analysis

IF - inferior frontal gyrus, encompasses motor speech area of Broca, damage usually results in paralysis of speech

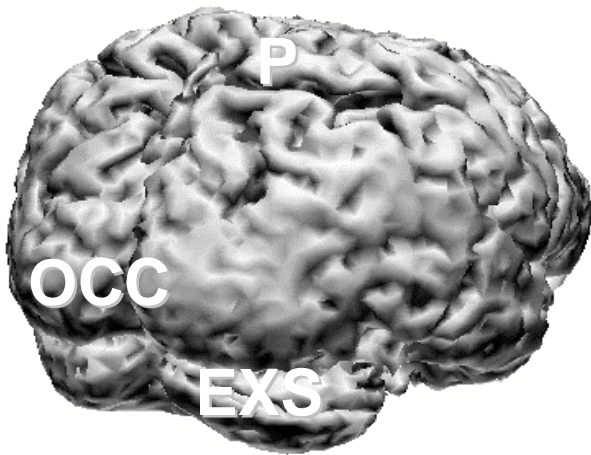
Figure 1: Brain Locations



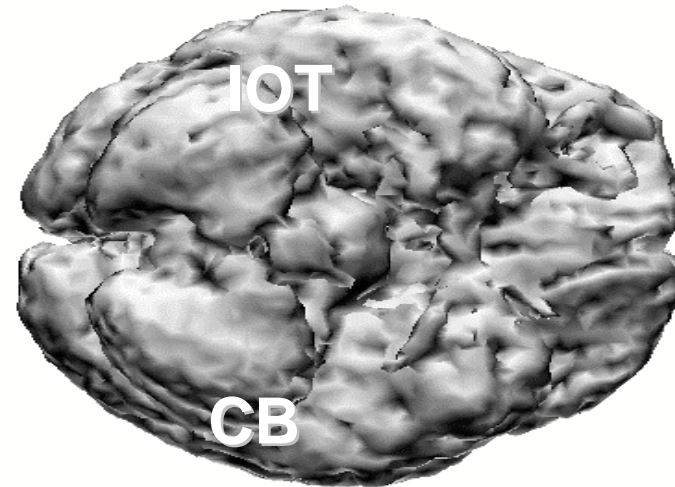
Left



Front

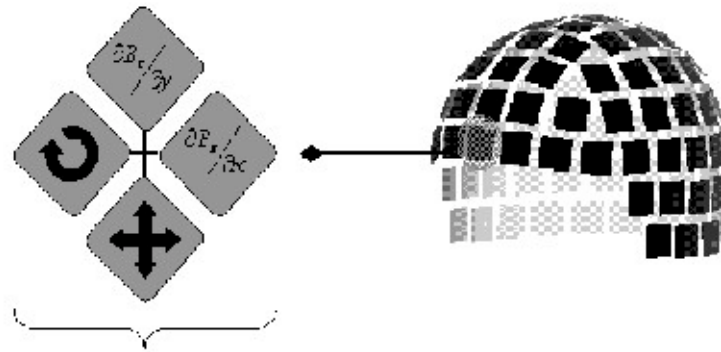


Back



Bottom

Figure 2: Measurement of Responses



Sensitive to tangential current flow below detectors

Figure 3: The overall time course of neural activity

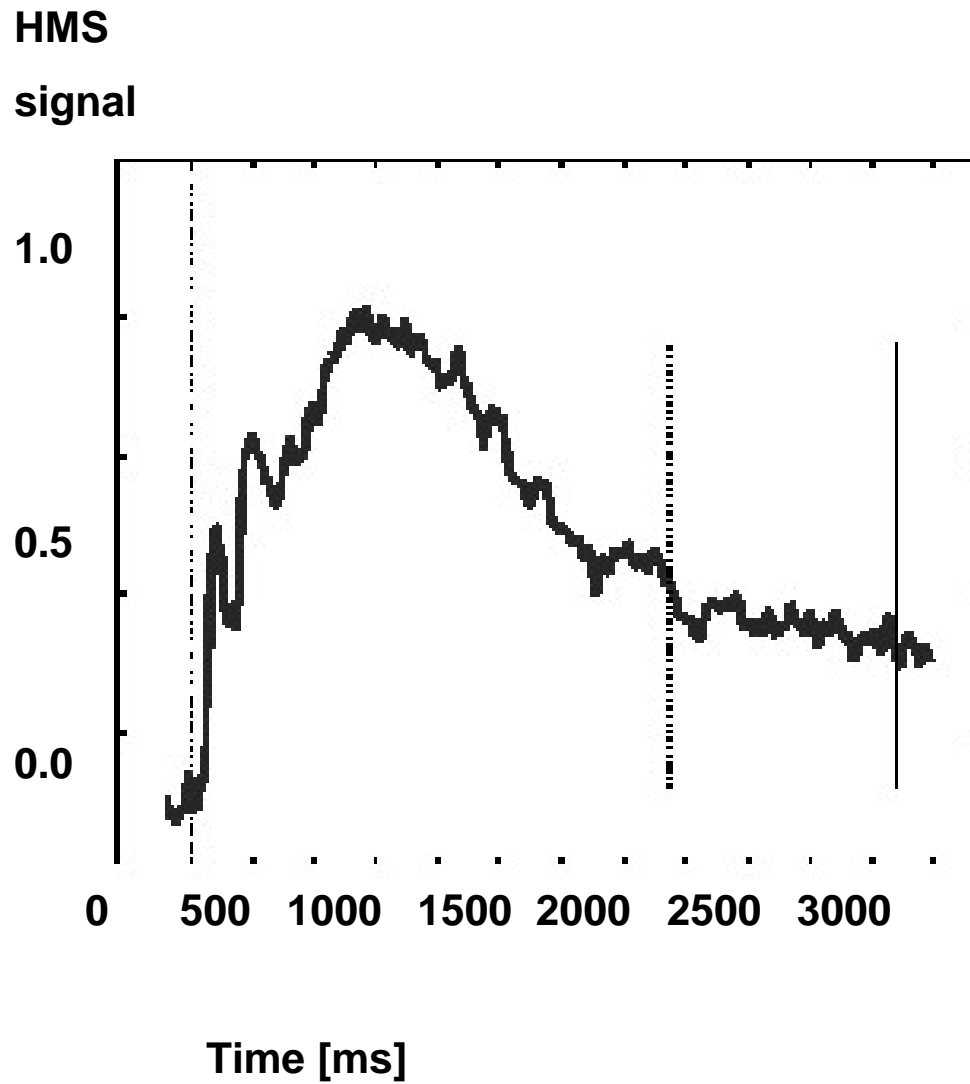


Figure 4 – Time lines of activations

