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Salience and Choice: Neural Correlates of Shopping Decisions

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ABSTRACT

Noninvasive brain imaging was used to observe 18 subjects, each making 90 choices of three brands on a virtual (video) supermarket visit. Package height provided a control for the main experiment. Brain activations in brand choice differed from those for height discrimination, and choice times were faster when one brand was more familiar. Brand choice appeared to involve silent vocalization. Decision processes took approximately 1 s and can be seen as two halves. The first period seems to involve problem recognition and here male brain patterns differed from female. The second half concerned the choice itself. No male/female differences were observed but a different pattern was evoked where one brand was familiar and the other two were not. The right parietal cortex was strongly activated in this case. This research pioneers new techniques using relatively few subjects and against a limited theoretical background. As such it must be classified as exploratory.

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Marketers are fundamentally interested in how consumers make buying decisions and now researchers can virtually look into their minds when they are doing so. Psychology is becoming increasingly anchored

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in neuroscience and the future perhaps lies in integrating approaches derived from the two scientific fields. This article reports experiments using a recent noninvasive brain imaging methodology, magnetoencephalography (MEG). It explores how brain activation differs according to brand familiarity.

Subjects undertook a virtual supermarket shopping experience in which, across 18 categories, they chose one brand or product from three alternatives. Brain activations were observed from the moment the brand choice was presented through the time when the decision was communicated by key press. Subjects were able to opt not to purchase at all.

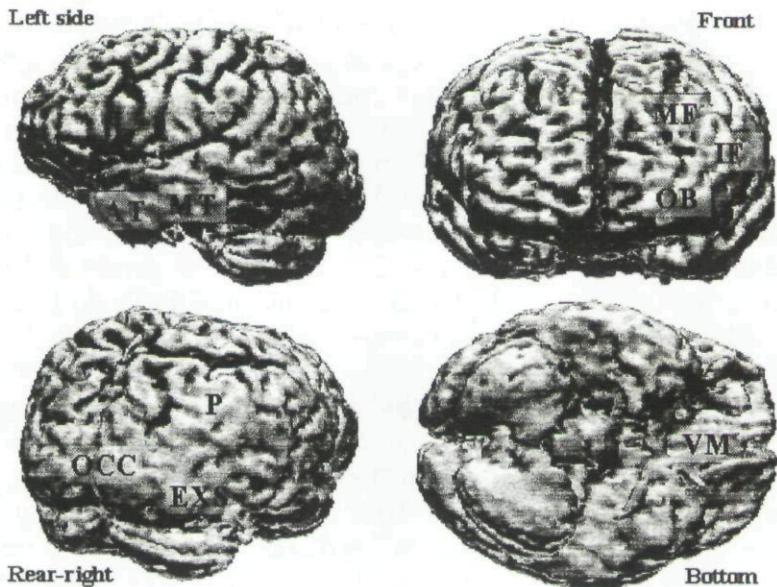
The article is structured as follows. A brief review of previous work leads to the issues for research. After describing the technology and methodology, the article presents the findings and limitations and draws managerial implications and conclusions.

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 components: reasons (thoughts, intention), emotions (wants, appreciation), and memories (habits, reinforcement, experience). Usage reinforces the emotional components that then act on the rationality and habit that finally drive behavior, that is, choice.

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 a highly integrative process, possibly feelings based, and 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 VM 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 down-stairs come together harmoniously in the ventromedial prefrontal cortices" (p.183). His findings are supported by Adolphs, Tranel, Damasio, and Damasio (1994) and Phelps and Anderson (1997). In other words, the location of brain activation during choice making may indicate the bases for those decisions. Furthermore, this research indicates feelings, rather than cognition, to be the crux.

This contrasts with the Cartesian, or rational optimizing, assumption



Key:

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

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

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

OB/MF – orbital/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 judgment.

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

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

VM – ventromedial frontal region; critical for normal decision-making according to Damasio.

Figure 1. Brain areas mentioned in the text.

often made about human behavior (e.g. Bettman, Luce, & Payne, 1998). In the rational model, choices are explained by comparing the attributes of the alternative brands and then trading off those attributes according to their desirability, (e.g. Bhargava, Kim, & Srivastava, 2000).

Bagozzi, Gopinath, and Nyer (1999), in reviewing the literature concerning the role of emotions in marketing, drew attention to the way emotional reactions to ads influence consumer decision making, but this attention has tended to focus more on processing the advertising (e.g., Agres, Edell, & Dubitsky, 1990; Ambler & Burne, 1999), than on decision making. Their first proposal for future research was to rebalance

that and examine how consumer appraisals are conducted, and in particular the roles of the amygdala, hippocampus, and other neural systems. This article now responds to that proposal.

Luce, Bettman and Payne (2001) considered emotional decisions and conceptualized consumer decision making as trading off various product attributes based on their emotional consequences; that is, the alternative outcomes are emotionally charged. This model, however, still adopts a fundamentally rational trade-off process, albeit 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) examined the effect of time pressure on context effects that are themselves due to consumers seeking to minimize the effort involved in making choices. Where choice was based on comparing the alternatives relative characteristics, less time increased the consistency of choice. For example, the brand leader would be chosen more often. When choice was based on absolute characteristics, more time made decisions more "accurate" in the sense of value maximization.

Finally, gender has been found to have a moderating effect on decision 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. 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; for example, women were relatively more successful at memorizing grocery (but not hardware) shopping lists than geographical directions. Furthermore, women are more likely to use shopping lists (Block & Morwitz, 1999).

ISSUES FOR RESEARCH

Broadly speaking, easier decisions, such as those based entirely on observed characteristics, would be expected to be quicker. Brand choice involves memory and probably emotional activation not required for a more simple discrimination task, for example, comparing the heights of three packages (Gross, 1995). Accordingly, reaction times for brand choice should be longer than for relative height determination (issue 1

or I1). Second, where one brand is more familiar than the others, the decision is likely to be faster than for equally familiar or unfamiliar brands (I2) (Dhar & Nowlis, 1999).

A variety of brain imaging studies has provided evidence for specific neural substrates associated with semantic processing and the memory-based interpretation of visually presented material (Braeutigam, Bailey, & Swithenby, 2001a; Damasio et al., 1996; McCarthy, Nobre, Bentin, & Spencer, 1995; Nyberg et al., 1996). Brain activation differences, therefore, should be observed between brand choice and height discrimination when the same visual images are used (I3).

The literature above leads to the expectation that male and female brain activations will differ (I4). And finally, in line with Damasio (1994), brand choice decisions were expected to be associated with activations in the frontal lobe (e.g., VM 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 height determination.

TECHNOLOGY AND METHODOLOGY

A number of measurement technologies now provide 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 several seconds (see, e.g., Aine, 1995).

An alternative is magnetoencephalography (MEG), a method that depends on the electrical character of neural signaling. 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. MEG can identify dynamic brain processes occurring on a millisecond time scale. This capability makes MEG a powerful tool when studying the rapid neural processes elicited by a choice-inducing stimulus. Hämäläinen et al. (1993) have provided an introduction to MEG.

In this technology, each subject has what appears to be a giant hair-dryer placed over his or her head as he or she sits watching a video screen and holding a key press for responses. There is no discomfort and after some initial activities to familiarize the subject with the technology and to allow the sense of artificiality to subside, the main experiment takes place.

Following initial piloting (22 subjects; no MEG recordings), the experimental design had three stages: a supermarket virtual tour to choose brands, a repeat of the tour in which subjects were asked to

choose the shortest item from amongst the choice of brands they were presented with, and, finally, the completion of a questionnaire to assess brand familiarity. The package height tests provided a control for the main experiment in that subjects were asked for decisions based purely on observation. As this was a separate experiment, it is termed the "control experiment" hereafter.

Eighteen participants (nine female, nine male, age between 30 and 63) participated in a simulated shopping trip with video footage of the interior of a supermarket in England, where all subjects had previously shopped, at least occasionally. The footage comprised 18 scenes as if they were 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 five static images after each video scene. These images constituted the actual stimuli. There were a total of 90 (18×5) one-out-of-three choices to be made ($90 \times 3 = 270$ items). The video lasted about 18 minutes. Participants were asked to indicate which of the three 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 pressed 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 would be used to provide a basket of the products selected during the MEG experiment. This was to discourage "buying" unwanted products.

Some time after the end of the simulated shopping trip, each participant completed a questionnaire with five-point scales, anchored by "very" and "not at all," to indicate familiarity with each of the 270 consumer items. For each subject and choice, a measure S of the salience, or relative familiarity of the chosen item, was calculated as follows:

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

where the V_c represents the questionnaire score of the item chosen and V_1 and V_2 represent the scores of the nonchosen items. S ranges from -4 to 4. The maximum is achieved if the item chosen (V_c) scores 5, whereas the two nonchosen items (V_1 and V_2) each score 1. Two respondents (one male, one female) did not give sufficient variance in their responses and these two questionnaires were discarded.

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 control experiment, participants were presented with a random sequence of 60 images drawn from those used in the main choice exper-

iment. 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 allowed 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.

Neuromagnetic responses following image presentation were recorded using a VectorView™ 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.

For each subject, all epochs were averaged according to task, gender, and high-low salience conditions within the interval – 200 to 1000 milliseconds (ms) where $t = 0$ denotes stimulus onset. Significant differences between pairs of evoked responses were sought with the use of a time-dependent measure DIFF (see Braeutigam, Bailey & Swithenby, 2001b):

$$\text{DIFF}(t) = \text{prob}(\chi^2), \quad \text{with } \chi^2 = -2 \sum_{i=1}^N \ln(W_i(t)),$$

where N (= 204) denotes the number of channels. w_i is the level of significance of a paired Wilcoxon test of evoked responses from subjects in the i th channel. For each channel i and time t , w investigates the differences between matched evoked amplitudes across subjects. Intervals with $\text{DIFF}(t) < 0.01$ were considered significant. For each such interval, the values w_i provided the spatial distribution of significance of differences between evoked responses. The latter was used to identify significant regions at the group level as well as individually.

RESULTS

Brand Familiarity and Choice

Overall there were 74 percent choices, a mean which masked individual differences—individual choices ranged from 58 to 97%. Females made more choices (82%) than males (67%). Familiarity as indicated by the questionnaire was a good predictor of choice. On the 5-point scale, the average score of the chosen items was 3.0 and of the non-chosen 2.1 (this difference is significant at $p < .01$).

As a consequence, salience was biased toward its maximum (4). The set of high-salience stimuli was dominated (82%) by trials in which the item chosen scored higher than either of the two nonchosen items. For

the remaining 18% of trials in this set, the item chosen scored at least 1 point higher than one of the nonchosen items. In 64% of low-salience trials, familiarity scores were equal or nearly equal for the three items. In the remaining 36% of cases in the low-salience set, the item chosen was less familiar than at least one of the other two.

Eight subjects who participated in the MEG study had performed the choice experiment during piloting. For these subjects, consistency of choice was 69% (out of 270 items). This consistency, while far from 100% was well in excess of random (33% if "no choice" is discounted). The shortfall was mainly accounted for by low-salience stimuli.

Nonchoice key presses significantly anticorrelated with familiarity scores across product categories ($\rho = -0.65$, $p < .004$). Despite this finding, the occurrence of nonchoices was too varied across subjects to allow further behavioral or MEG analysis of these trials.

Reaction Times

Reaction times were defined as the time-span from onset of image to key press. Subjects responded significantly ($p < .001$) faster to high-salience stimuli (average key-press at 2265 ms) than to low-salience stimuli (2735 ms). Decision making in the control experiment was much faster than the main (brand choice) experiment, and subjects responded by pressing the appropriate key on average 930 ms after the stimulus. In the control condition, the occurrence of 'cannot discriminate' presses was negligible (< 0.4%). Females responded slower than males in the height control experiment ($\Delta = 195$ ms; $p < .01$) but faster in the brand choice experiment (240 ms on average; $p < .001$).

Neural Activity

Evoked responses elicited by the choice condition exhibited a complex pattern in time and space across subjects. These responses were suitable for analysis within a time range 0 to about 1000 ms after stimulus onset. At longer latency, the consistency of neural activity with respect to the inducing stimulus was lost. In the control experiment, evoked responses were suitable for analysis for latencies up to about 300 ms. At longer latency (>500 ms), evoked responses were associated with the motor activity required by the ensuing key presses.

With the use of measure DIFF, four characteristic intervals were identified, where neural activity is modulated by either task condition, gender, or salience. All effects hold at the group level, as well as individually in at least 13 of the 18 subjects. These intervals form a timeline of characteristic events depicted in Figure 2, and briefly described below (see Figure 1 for brain areas mentioned in text).

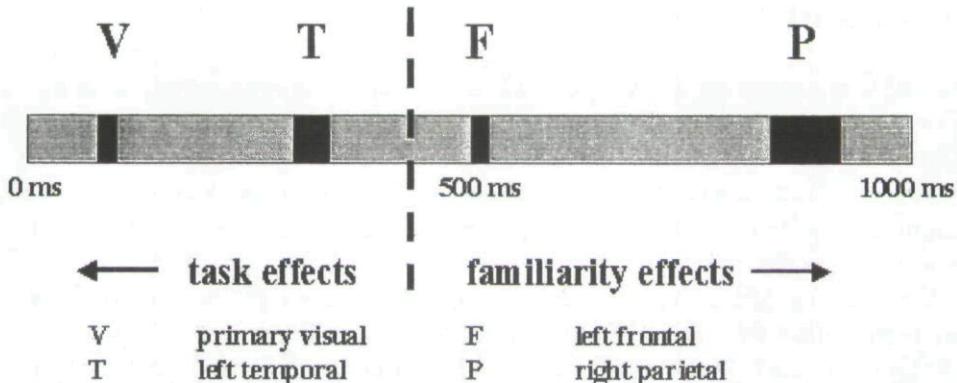


Figure 2. The four distinct brain activation stages.

Stage 1—V (visual): Responses over primary visual cortices (OCC in Figure 1) at around 90 ms after stimulus onset. Signal amplitudes were highest in the choice task, and lowest in the height control experiment.

Stage 2—T (temporal): Neuronal activity predominantly over left anterior-temporal and middle-temporal cortices (AT and MT) at around 325 ms after stimulus onset. Some specific activity was also found over left frontal (MF and OB), and right extra-striate (EXS) cortical areas. Within this latency range, signal amplitudes following presentation of the images were higher when choosing an item as opposed to determining the shortest item.

Stage 3—F (frontal): Responses over left inferior frontal (IF) 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. These signals over IF are consistent with activation of Broca's speech area.

Stage 4—P (parietal): Responses over right posterior parietal cortices (P) 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.

Male brain activity differed from female in the second stage (T) but not in the other three stages (V, F and P). Left anterior temporal activity is present in both groups, but males seem to activate right hemispherical regions much more strongly during memory recall than females do. As noted above, response times also differed for male and female subjects. On the other hand, as discussed below, there were no salience effects in the first two stages (V and T), but these were significant in the later two stages.

DISCUSSION

Familiarity appears to be a useful indicator of likely buying behavior. Furthermore, the longer response times for low-salience stimuli implies some degree of perplexity in making a choice. The magnetoencephalographic results averaged across all subjects revealed a robust temporal sequence of neural responses. This sequence decomposes into four differential stages.

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 condition. One might argue that a complex stimulus has to be strongly represented in occipital cortex for subsequent higher analysis; that is, the early response to the brand picture is affected by the purposes intended for perception. The complexity of the image may have influenced this representation. 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, Rees, Frith, & Lavie, 2001).

The later response (T) was also stronger in the consumer choice task. These responses are similar to signals known from a variety of studies to be engaged in semantic processing and the memory-based interpretation of visually presented material (Braeutigam, Bailey, & Swithenby, 2001b; Damasio et al., 1996; McCarthy et al., 1995; 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, usage, 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 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 shape or linguistic information.

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 typically a strong familiarity with one of the three brands/products. The parietal cortex is a large and complex region, some parts of which are associated with the planning of motor activity, and other parts receive converging input

from many sources, making it available for second-order mapping, such as in relating spatial to other representations (Anderson & Zipser, 1990). Lesions of the right parietal cortex can affect the human capacity to produce speech with normal prosody (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 can adversely affect a person's intentionality (Charlton, 2000; Damasio, 2000). Thus such lesions may 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, in cases when familiarity is strong (in this choice task), decision making may relate to just those processes where the outcome is consistent with some form of intention. The parietal response may also signify a strong attentional focus on the item already chosen, in order to visually "hold" it during ensuing motor control necessary for the key press. This is consistent with the role of the right parietal cortex in selective and sustained attention processes (Cabeza & Nyberg, 1997; Vallar, 1997), and processes of motor control (Kandel, Schwartz, & Jessell, 1991).

In summary, additional to the five research issues, two findings were unexpected. The first research issue concerned reaction times, which, as expected, proved to be longer for brand choice than for height determination (I1). Second, the decision times were shorter for high-saliency brands (I2). Brain activation differed between brand choice and height discrimination when the same visual images were used (I3).

The two unpredicted findings were the activation of Broca's area in low-salience conditions and, for high-salience conditions, the strong activation of the right parietal cortex, which may imply intentionality for purchase.

As noted above, males and females differed in reaction times for brand choice and height discrimination and in the temporal (T) processing stage but not in the other three stages (I4). Brand choice decisions were not found to be associated with activations in the frontal lobe as suggested by Damasio (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

By the conventional standards of marketing research, the sample size was small and that also prohibited the rotation of stimuli. Framing or sequence factors should not have affected these results but the possi-

bility exists. It would be interesting to replicate this work with different sequencing to test the issue.

Response times may have been affected by the familiarity of subjects with the supermarket shopping experience. According to an informal debriefing, shopping frequency was balanced within the current groups of subjects, but this issue should be investigated more rigorously in future research to distinguish gender from practice effects and involvement (Fischer & Arnold, 1990). It may also influence the activation of rational, affective, and memory parts of the brain. Damasio's (1994) thesis was that nonhabitual 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.

This research considered the brand choice stage of marketing activity. To better understand the roles of marketing communications and memory of previous brand usage, brain imaging should compare all three stages within a single, albeit multistage, experiment. Finally, all these brands and categories were assumed to be similar. Research is needed both to assess differences within supermarkets and brands and with other types of products, for example, purchasing cars.

CONCLUSIONS

From the point of view of practitioners, brain imaging of decision making has been demonstrated to be possible. That brand choice engages the brain longer, and in more complex ways, than height discrimination is not surprising. More interesting is the finding that the brain appears to use vocalization actively in that choice process. 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. The correlation with the subject's familiarity with that brand is relevant here to the theme of brand equity, that is, consumers' memory of the brand. Neither the right parietal activity nor the associated brand salience explains 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.

This technology will not be available to marketers for routine packaging and consumer decision making research for many years to come, but some key areas for exploration are becoming apparent, for example, the impact of advertising on salience and the other aspects of brand equity that can be discovered by imaging. Marketers would like to know what is being vocalized in low-salience conditions. Branding is supposed to simplify consumer decision making and make it easier to make faster

decisions. This article supports that supposition and indicates a brain imaging path to be followed.

Linking these events through the advertising, experience, and choice processes requires further research. The complex mechanisms underlying shopping behavior may draw on the specificity of individuals' past experience and engage many interacting sociopsychological processes not explored here.

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