Brain activity correlates of consumer brand choice shift associated with television advertising

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This study uses brain activity measures to examine the relationship between television advertising and changes in consumer brand preference. Prior to and after viewing a television programme that included grocery advertisements 198 right-handed females selected six 'door prizes' from six grocery categories. One of the advertisements featured a jam that was available as a door prize. Steady-state topography (SST) was used to estimate brain activity at eight scalp sites, including left and right lateral prefrontal sites previously shown to index the strength of long-term memory (LTM) encoding. Our hypothesis, that lateral prefrontal activity would be higher during branding for the 18 participants who shifted to the advertised jam compared to those consistently selecting the competitor jam, was confirmed, but only for the left hemisphere. Our findings suggest that SST activity at lateral prefrontal sites during television advertisement branding may be a useful indicator of advertising effectiveness.

Introduction

Over the last ten years there has been a significant increase in research on the neural basis of economic decision making (for a review, see Braeutigam 2005). One aspect of this field that is receiving significant attention concerns the neural basis of consumer or purchase decisions. The majority of such studies describe brain activity patterns immediately prior to and during decision making. For example, Ambler *et al.* (2001,

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2004) used magneto-encephalography (MEG) to examine changes in rhythmic brain activity while subjects shopped at a virtual supermarket. They reported that a late burst of high-frequency (gamma) MEG activity over the parietal cortex was associated with the selection of brand choice.

More recently, a number of studies have applied functional magnetic resonance imaging (fMRI) to examine brain activity during brand choice or simulated purchase. The reader is referred to an excellent review on the application of fMRI in market research by Kenning *et al.* (2007). A number of fMRI studies have specifically addressed the issue of brand preference. Paulus and Frank (2003) used fMRI to examine the distribution of neural activity during a personal preference choice of alternate consumer brands, as opposed to a perceptual judgement. They reported increased activity in the ventromedial prefrontal cortex for trials where subjects were required to make personal preference choice, consistent with the 'somatic marker' hypothesis proposed by Damasio *et al.* (1996). Deppe *et al.* (2005) used fMRI to examine brain activity changes during the period subjects were required to make a choice between alternate brands of either coffee for females or beer for males. They found that the process of selection was associated with a 'winner-takes-all effect' for the subject's preferred brand, with a reduction of activity in a number of areas, including the dorsolateral prefrontal cortex, and increases in the superior frontal gyrus and ventromedial prefrontal cortex. The authors interpret these findings to suggest brand preference choice was associated with reduced cognitive processes such as working memory and increased activity at sites mediating emotional processes.

A study by Schaefer *et al.* (2006) examined the neural correlates of car manufacturer brands. The authors reported increased medial prefrontal cortex activity when subjects were presented with a familiar as opposed to an unfamiliar car brand. The authors attribute the different pattern of activation – that is, medial prefrontal as opposed to ventromedial prefrontal – to differences in the experimental design. While studies requiring subjects to make a choice or otherwise indicate their preference shortly after presentation of the alternatives are associated with increased ventromedial prefrontal activity, the Schaefer *et al.* study required subjects to imagine themselves driving or using a car of the brand symbol (logo) presented.

A more recent study, by Knutson *et al.* (2007), examined the interaction between product preference and product price. They reported that product preference activated neural circuits, including those associated with anticipated gain, such as the medial prefrontal cortex and nucleus accumbens, while excessive price activated regions such as the insular cortex, thought to be associated with negative affective states such as pain anticipation and disgust.

A significant feature of these studies is that they report on the immediate brain responses following brand exposure. The interval between brand exposure and choice is typically less than 5 seconds and thus it is reasonable to assume that this may be utilising short-term or working memory. By contrast, there is typically a considerable interval (varying from hours to weeks) between the time a consumer is exposed to advertising promoting a particular brand and the time that a relevant brand choice is made. There have been few neuroscience studies examining the relationship between brain activity while viewing television advertising *and subsequent changes* in consumer choice, where the interval between advertising viewing and consumer choice is long enough to rely on long-term memory (LTM). While brain activity in various regions has been associated with immediate brand choice, for a television commercial to influence brand choice over a subsequent period of, at a minimum, hours to weeks, brand information included in the television commercial must be encoded effectively in one or more forms of LTM (Ambler & Burne 1999). In making this statement, we wish to distinguish between the processes of information or experiences being stored or 'encoded' in LTM and the various measures used in advertising research to determine which components of an advertisement have been encoded in LTM. Market researchers frequently use measures of either recognition or recall as indicators of the presence of specific information – typically advertising or brand information – in LTM.

While successful recognition or recall of a piece of information implies that this information was previously encoded in LTM, the converse does not apply. That is, failure to remember or recognise a piece of information does not necessarily mean that this information has not previously been encountered and encoded in LTM. A significant and growing body of neuroscience and advertising research studies points to the importance of unconscious and implicit memories (Schacter 1987; Shapiro *et al.* 1997; Shapiro & Krishnan 2001; Heath & Nairn 2005). Furthermore, such implicit memories can have a significant influence on consumer attitude and behaviour (North *et al.* 1999; Fitzsimons *et al.* 2002). Thus, any study examining the relationship between brain activity while viewing television advertising and subsequent changes in consumer choice should not rely solely on explicit memory measures, but use a methodology that reflects the influence of both explicit and implicit memory processes.

One approach to measuring the effectiveness of advertising that does not rely exclusively on explicit memory is the persuasion shift methodology (Adams & Blair 1992; Rossiter & Percy 1997). Here, consumers are given the opportunity of selecting a number of consumer goods from a range. Consumers then view advertisements, generally in an advertisement block in a television programme where one of the consumer goods brands that is available is featured in an advertisement. After viewing the programme, consumers are required to make a new choice from the consumer goods. The net shift in the proportion of consumers selecting the advertised brand is considered a measure of the 'persuasion shift' and the likely effectiveness of the advertisement.

As a behavioural measure, the persuasion shift is not dependent exclusively on measures of explicit memory and we decided to use this methodology to examine the relationship between brain activity while viewing television advertising and subsequent changes in consumer choice. In particular, we report on a study examining the relationship between brain activity indicators of LTM encoding of television advertisement branding and subsequent changes in consumer choice.

To examine the relationship between LTM encoding of branding in television advertising and subsequent consumer choice requires a methodology that possesses sufficient temporal resolution to indicate the level of LTM encoding during the period that branding occurs in the advertisement. In this study, we used steady-state topography (SST), a methodology capable of tracking second-by-second changes in brain activity. As readers are likely to be less familiar with SST than other brain imaging techniques based on EEG, MEG or fMRI, we take this opportunity to briefly describe it in more detail.

Steady-state topography (SST)

Non-invasive recordings of human brain electrical activity can be roughly subdivided into two classes, namely spontaneous or ongoing activity – also known as the electroencephalogram (EEG) and 'event-related activity', where a sensory or cognitive event is associated with a change in brain electrical activity known as an event-related potential (ERP). Steady-state topography (SST) is an ERP-based methodology. The key feature is that a dim ongoing oscillating visual stimulus is presented in the peripheral visual field while subjects are performing a cognitive task or, in this case, viewing a television advertisement. This oscillating visual stimulus is present the whole time and it elicits a small brain rhythmic sinusoidal response at the stimulus frequency that is termed the 'steady-state visually evoked potential' (SSVEP). The SSVEP is completely characterised by the amplitude and the phase difference between the stimulus signal and the SSVEP, and is frequently represented as a complex number. Variations in the SSVEP phase difference reflect changes in latency or delay between the SSVEP signal and the visual stimulus. These latency changes have been suggested to reflect summed changes in synaptic transmission time related to synaptic excitatory or inhibitory processes where a latency reduction is considered to index increases in synaptic excitation (or a reduction in synaptic inhibition), while a latency increase indicates a reduction (Silberstein 1995). For simplicity, we will subsequently refer to SSVEP latency reduction or increased excitation as 'SST activity', and express it in radian units. In the current study, SST activity of $2*\pi$ radians corresponds to a latency difference of 77 milliseconds (ms) or one stimulus cycle.

Three specific features of the SST methodology make it a useful technique in cognitive neuroscience research as well as neuroscience-based advertising research.

1. High temporal resolution: the SST technique is able to continuously track rapid changes in brain function (Silberstein 1995). This is an important feature as many changes in brain function associated with TV advertising reflect the pace and changes in the advertisement and can occur in less than a second.
2. High signal strength (or high signal-to-noise ratio) and resistance to interference and 'noise': the mathematical technique used to estimate the SST activity means that it is possible to tolerate very high levels of noise or interference due to such things as head movements, muscle tension, blinks and eye movements (Silberstein 1995). This makes SST well suited to cognitive studies where eye, head and body movements occur as a matter of course.

3. The high signal-to-noise means that it is possible to work with data based on a single trial per individual (Silberstein *et al.* 1990) as opposed to the typical situation encountered in event-related potential (ERP) or event-related fMRI studies where there is a need to average multiple trials recorded from each individual to achieve adequate signal-to-noise ratio levels.

While SST, in common with other electrical or magnetic recording techniques, possesses high temporal resolution, it has relatively low spatial resolution, especially compared to fMRI. Furthermore, the SST measure primarily reflects activity in the cortex and is not able to reliably measure activity at deep brain regions beneath the outer layer of the cortex (Nunez *et al.* 1994).

SST has been used in numerous studies of both normal brain function, such as visual attention (Silberstein *et al.* 1990), working memory (Silberstein *et al.* 2001; Perlstein *et al.* 2003; Ellis *et al.* 2006), visual imagery (Silberstein *et al.* 2003) and decision making (Silberstein *et al.* 1995), as well as changes associated with emotional processes (Kemp *et al.* 2002, 2003, 2004; Gray *et al.* 2003). SST has also been used to study disturbed brain function such as attention deficit hyperactivity disorder (ADHD) (Silberstein *et al.* 1998) and schizophrenia (Line *et al.* 1998; Silberstein, Line *et al.* 2000).

Of particular relevance to the current study is a previous SST study examining the relationship between lateral prefrontal activity while subjects watched television advertisements, and subsequent recognition of specific images featured in the advertisements (Silberstein, Harris *et al.* 2000; Rossiter *et al.* 2001). This study was based on a large and growing body of neuroscience research suggesting that cortical activity at the lateral prefrontal cortex predicts the strength of long-term memory traces (Rugg 1996; Brewer *et al.* 1998; Kelley *et al.* 1998; Buckner *et al.* 1999; Smith & Gevins 2004). In Silberstein, Harris *et al.*'s (2000) study, 35 female participants viewed ten unfamiliar television advertisements organised as two blocks in a documentary programme, while brain activity was recorded at eight scalp sites that included the left and right medial prefrontal sites (midway between Fp1 and F7 on the left, and Fp2 and F8 on the right), left and right lateral prefrontal sites (midway between F7 and C3 on the left, and midway between F8 and C4 on the right), left and right prefrontal sites (F3 and F4), and left and right occipital sites (O1 and O2). We hypothesised that, after a delay of seven days, the images associated with increased lateral prefrontal SST activity would be recognised better than images associated with reduced frontal excitation. The hypothesis was robustly confirmed, although only for the left hemisphere prefrontal site (paired *t*-test, $t = 7.11$, df = 34, $p = 3.2 \times 10^{-8}$). To determine whether this effect was specific to the lateral prefrontal sites or represented a more generalised phenomenon such as arousal, we examined the correlation between recognition memory performance after the seven-day delay and SST activity at all eight recorded sites. We reasoned that if the effect observed at the lateral prefrontal was a manifestation of a more widely distributed change in brain activity, such as due to arousal, we would observe a correlation between memory performance and SST activity at all sites. In fact, we found that the correlation between recognition memory performance and SST activity reached statistical significance only at the left lateral prefrontal site when Bonferonni corrections were made for multiple comparisons (left prefrontal site $r = 0.45$, df = 39, $p < 0.005$). Interestingly, the correlation between occipital SST activity, presumably reflecting visual attention (Silberstein *et al.* 1990), and recognition memory was weakest at the left and right occipital sites (left occipital, $r = 0.16$, right occipital $r = 0.01$, df = 39, $p > 0.05$), suggesting that memory performance was not driven by changes in visual attention.

These findings are consistent with the extensive body of evidence pointing to the critical role of the lateral prefrontal cortex in encoding information into LTM. While the above-mentioned findings relate specifically to explicit memory in that we used recognition as an indicator of LTM encoding, it is important to note that the frontal cortex plays a crucial role in LTM encoding, irrespective of whether it subsequently exists as explicit or implicit memory (Buckner *et al.* 2000; Paller *et al.* 2003).

In the current study, we examine the relationship between SST activity indicators of LTM encoding of branding segments in a television advertisement and the subsequent change in consumer preference for the advertised brand. The design of the study was similar to the 'persuasion shift' methodology mentioned previously (Adams & Blair 1992; Rossiter & Percy 1997). In this methodology, participants are invited to make a series of product choices before and after viewing advertisements. Proportional changes in the number of participants choosing the advertised product are said to reflect the 'persuasion shift' and hence the likely commercial effectiveness of the advertisement. If we assume that LTM encoding of brand identity is a necessary condition for advertising effectiveness, then we should expect that a shift in consumer choice to an advertised brand following a single viewing of a novel (or unfamiliar) television advertisement will be associated with increased LTM encoding for brand information occurring in the advertisement. Specifically, we hypothesise that, compared to participants whose brand choice does not change from the competing brands, those who change their choice to the advertised brand will exhibit larger LTM encoding for those points in time where brand information is presented explicitly in the advertisement.

Methods

The participants comprised 198 right-handed females aged 25–45 (mean age 38.2 years), who were recruited through a Melbourne-based market research recruitment agency. Apart from gender and handedness, the only other selection criterion was that participants were the principal shopper for food and groceries for the participant household. All subjects received a payment for their participation.

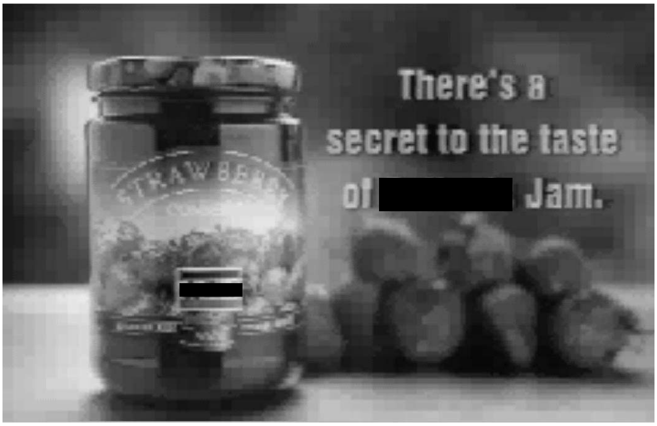
The study was conducted in a purpose-built facility at the Brain Sciences Institute, Swinburne University of Technology, and was approved by the Swinburne University Human Experimentation Ethics Committee.

On arriving at the venue, participants were asked to choose six products from a range of 'door prizes' located in a display case. Door prizes were selected from within six different product categories: toothpaste, spaghetti, sliced peaches, breakfast cereal, carbonated soft drink and jam. Three equivalently priced products were available for selection from within each food category, giving each subject six choices of three products. Products within each category were displayed on one of six shelves in the display case, with shelf order counterbalanced across subjects. After making their choice of six products, participants viewed a 20-minute video featuring a documentary programme interspersed with two advertising breaks, each comprising four television advertisements. One of the television advertisements, for a particular brand of jam that was available as a door prize and the focus of this study, was always located as the second advertisement in either the first or second advertising break. Note that subjects viewed each commercial only once. In order to mask the advertising-related aspect of the study, participants were asked after viewing the video to rate various aspects of the performance of the documentary narrator. After rating the documentary, research staff used a standard script to invite participants to make another selection of the six door prizes. The time interval between participants viewing the target advertisement and making their second selection of door prizes was 25–30 minutes.

The television advertisement selected for the study was 45 seconds in duration and featured a popular brand of jam. At the time of the study, the advertisement had not yet been released to appear on Australian commercial free-to-air television, while the other seven advertisements had already been released at the time of the study. The advertisement was humorous and featured two male ‘employees’ of the producer who proceeded to ‘reveal’ the ‘secret’ behind the ‘superior’ taste of the advertised brand. Explicit components of the advertisement that featured the brand name and product for more than 1 second occurred at the start of the advertisement (approximately 2 seconds into the advertisement) (Figure 1) and near the end (approximately 38 seconds into the advertisement) (Figure 3); these will be referred to as initial branding and final branding segments respectively. The duration of the initial branding segment was approximately 2 seconds, while that of the final branding segment was approximately 3 seconds. A key part of the advertisement message – the revelation of the ‘secret’ – occurred approximately 28 seconds into the advertisement (Figure 2).

After giving informed consent, brain electrical activity was recorded from eight participants at a time, while they viewed the video material. The material was presented on a video monitor with vertical and horizontal dimensions of 60 cm and 80 cm, respectively. Seating for the subjects was organised as two rows, each comprising four seats. Depending on the seating location, the width of the screen subtended at an angle of between 7.5 and 13 degrees. Brain electrical activity was recorded from eight scalp electrodes positioned over the medial prefrontal (midway between Fp1 and F7 on the left, and midway between Fp2 and F8 on the right), lateral prefrontal (midway between F7 and C3 on the left, and F8 and C4 on the right), left and right prefrontal (F3 and F4), and left and right occipital (O1 and O2). All recording sites were referenced to linked mastoids.

Figures 1, 2 and 3: Frames from the initial branding (Figure 1), the scene where the 'secret' of the target-brand jam is 'revealed' (Figure 2) and final branding (Figure 3) (note that the identity of the brand has been obscured)



We note that the number of recording electrodes is small by current standards and may raise the question of whether the recording configuration we used will have sufficient spatial resolution to assess the hypothesis. We suggest that, while our system possesses limited spatial resolution, our previous LTM study (Silberstein, Harris *et al.* 2000), on which the current hypothesis is based, suggests that there is sufficient resolution to test the hypothesis. Specifically, in the previous study we showed that LTM performance was most strongly correlated with SST activity at the left but not the right lateral prefrontal electrodes, and was not at all correlated with SST activity at occipital sites. Furthermore, while not reaching levels of statistical significance, we found large variations in the correlation between SST activity and memory performance for the other five prefrontal sites. In other words, we observed sufficient SST spatial variation to test the hypothesis that LTM performance was correlated with SST activity recorded at lateral prefrontal scalp sites.

The stimulus used to evoke the SSVEP was a white 13 Hz sinusoidal flicker subtending at a horizontal angle of 160 degrees and a vertical angle of 90 degrees. The modulation depth of the stimulus when viewed against the background was 45%. A set of goggles that permitted the sinusoidal flicker to be superimposed on the viewing field was used to present the stimulus (Silberstein *et al.* 1990).

The major features of the signal processing have already been described (Silberstein 1995). Briefly, the SSVEP was determined from the smoothed 13 Hz EEG Fourier coefficients derived from EEG data recorded while participants viewed the video material. The smoothed Fourier coefficients were pooled separately for two groups of participants: those who did not change their choice of one of the two competitor brands and those who shifted from the competitor brands to the target brand.

We used a non-parametric statistical methodology, specifically a multivariate permutation test (Blair & Karniski 1993), to assess the statistical significance of the SST difference between the shift-to-target brand group and the no-change group for the early and late branding times. In this approach, we compare the actual SST difference between the two populations with the distribution of 10,000 differences derived by randomly reallocating the individual SST differences. This yields an exact p value that does not rely on any assumptions of equality of variances or normal distribution, and also tends to be more conservative than the parametric methodologies.

Results

Table 1 summarises the number of participants choosing the target or competitor brands, as well as those who changed their selection to the advertised brand (away from the competitor brand) and those who changed their selection to the competitor brand (away from the advertised brand).

While the net shift to the advertised brand was ten subjects (5%), 18 participants changed their choice from the competitor brands to the advertised brand, and eight changed their choice from the target brand to the competitor brands.

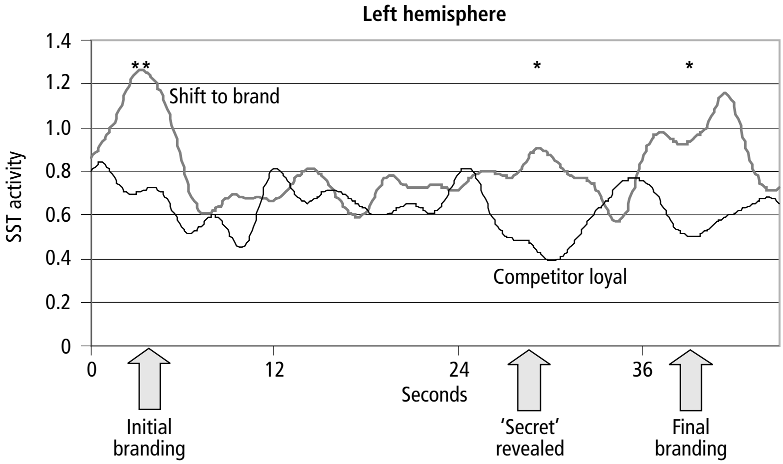
To test the hypothesis of this study, we examined the SST activity at the left and right lateral prefrontal sites for the group of 18 participants who changed their choice to the advertised brand (shift-to group) and the group of 111 participants who did not change their choice from the competitor brand (competitor-loyal group). The left lateral prefrontal SST activity for the two groups while viewing the advertisement is illustrated in Figure 4. Figure 5 illustrates the equivalent activity measure for the right lateral prefrontal sites. SST activity at these sites has previously been demonstrated to index the strength of LTM encoding. The solid arrows indicate, in order from left to right, the mean timing of the initial branding, the revelation of the 'secret' and the final branding sequences for the advertisement.

At the left lateral prefrontal site, there are three points in time where SST activity for the shift-to group that shifted to the advertised brand (tinted trace) is significantly larger than the equivalent activity for the competitor-loyal group. These are at the times of initial branding segment

Table 1: Row 1 gives the distribution of the initial choice of participants between the advertised and competitor brand; row 2 illustrates the number of participants who shifted to the advertised or competitor brand after viewing the advertisements, while row 3 gives the number of participants selecting the advertised brand and the competitor brand after viewing the advertisements

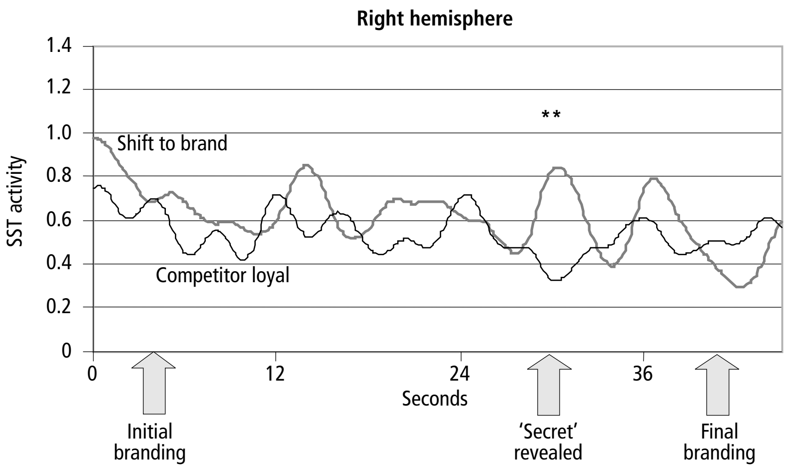
Choice	Advertised brand	Competitor brand
Initial brand selection	69 (34.8%)	129 (65.2%)
Change to brand	18 (9.1%)	8 (4.0%)
Final brand selection	79 (39.9%)	119 (60.1%)

Figure 4: SST activity at left lateral prefrontal site for the group that shifted to the advertised brand (tinted line) and the group that was competitor loyal (black line); the heavy arrows indicate the points in time corresponding to initial branding, the revelation of the 'secret' and final branding



Notes:
1. The unit of SST activity is expressed in radian units. In the current study, SST activity of 2*π radians corresponds to a latency difference of 77 msec.
2. Asterisks indicate the following permutation test probabilities associated with the SST activity difference between the group that shifted preference to the advertised brand and the competitor-loyal group. $**P < 2\%$; $*P < 5\%$.

Figure 5: SST excitation at right lateral prefrontal site for the group that shifted to the advertised brand (tinted line) and the group that was competitor loyal (black line); the heavy arrows indicate the points in time corresponding to initial branding, the revelation of the 'secret' and final branding



Notes:
1. The unit of SST activity is expressed in radian units. In the current study, SST activity of 2*π radians corresponds to a latency difference of 77 msec.
2. Asterisks indicate the following permutation test probabilities associated with the SST activity difference between the group that shifted preference to the advertised brand and the competitor-loyal group. $**P < 2\%$.

(permutation test, $p = 1.2 \times 10^{-2}$) and final branding segment (permutation test, $p = 3.3 \times 10^{-2}$). The only other point in time where left lateral prefrontal SST activity difference between the groups reaches significance is when the 'secret' is revealed (permutation test, $p = 2.2 \times 10^{-2}$). By contrast, at the right lateral prefrontal site, the only time that the SST activity for the shift-to group is significantly larger than the equivalent SST activity for the competitor-loyal group is when the 'secret' is revealed (permutation test, $p = 1.9 \times 10^{-2}$).

Table 2 lists the SST activity at initial and final branding segments for both groups at all the recording sites. We include the results of the permutation-based statistical test for all sites for illustrative purposes as our hypothesis was based on our previous study and explicitly addressed SST changes at the lateral prefrontal sites only.

Table 2: SST activity at initial and final branding segments for the group that shifted their choice to the advertised brand (shift-to group) and the group that selected a competitor brand (competitor-loyal group) for the eight recording sites; the cells shaded with a dark tint indicate a significant difference in SST activity between the groups at the 2% level or better, while the cells shaded with a light tint indicate a significant difference at the 5% level

	Initial branding		Final branding	
	Shift-to brand	Competitor loyal	Shift-to brand	Competitor loyal
Left medial prefrontal	0.77	0.71	0.52	0.46
Right medial prefrontal	0.95	0.72	0.38	0.46
Left lateral prefrontal	1.26	0.70	0.94	0.50
Right lateral prefrontal	0.73	0.64	0.52	0.46
Left prefrontal	0.98	0.80	0.37	0.70
Right prefrontal	1.20	0.72	0.71	0.54
Left occipital	0.80	0.79	0.65	0.66
Right occipital	1.29	0.74	0.91	0.65

Discussion

To the best of our knowledge, this is the first neuroscience demonstration of the link between LTM encoding for brand information in a television advertisement and a shift in consumer preference to the advertised brand. While such a link has been assumed implicitly or explicitly for as long as advertising has existed, the specific neural mechanisms underlying this link have not previously been demonstrated. Our findings suggest that LTM encoding for brand information may be a useful indicator of advertising effectiveness – that is, the capacity to favourably influence consumer choice.

However, before discussing the findings further we wish to comment on some issues concerning the specificity of our findings – in particular, whether our findings could be accounted for by changes in visual attention or working memory. In considering this question, it is important to note that while the left lateral prefrontal site was the only one that demonstrated a consistent statistical difference between the groups for both branding segments, we did observe indications of greater SST activity in the shift-to group at the right prefrontal (F4) and right occipital (O2) sites at the initial branding epoch only. The findings at the right prefrontal and occipital sites are consistent with increased engagement of visual attention and working memory processes in the initial branding segment for the shift-to group compared to the competitor-loyal group (see Silberstein *et al.* 1990, 2001). While our data suggest that increased engagement of visual attention and working memory processes at the initial branding segment in the shift-to group is not inconsistent with the role of the prefrontal cortex in modulating attention and mediating working memory, a number of factors lead us to suggest that these processes alone cannot account for our findings. First, it is only the left lateral prefrontal site that demonstrates a consistent difference for both branding segments. Had visual attention or working memory processes alone played the key role, we would have expected the occipital and prefrontal difference between groups to be apparent during both branding segments. Second, our earlier memory study (Silberstein, Harris *et al.* 2000) indicated that long-term memory performance was correlated significantly with SST activity only at the left lateral prefrontal site; in fact, the occipital sites showed the least evidence of any correlation between SST activity and recognition memory performance. Finally, the scientific literature briefly reviewed in the introduction and discussed further below suggests a principal role for the lateral prefrontal cortex in encoding LTM. In summary, while we do not discount SST findings that point to increased visual attention and working memory processes in the shift-to group during the first branding segment only, we do not believe that these processes alone can account for our findings.

Another issue that should be addressed is that the test commercial was seen by participants for the first time in this study while other commercials that served as foils had previously been broadcast on free-to-air television. Could the novelty of the test ad compared to the foil commercials somehow account for our findings? We think this is unlikely as the test advertisement was novel for all participants. If the relative novelty of the test commercial somehow accounted for our findings then this implies that the foil commercials were more familiar to the shift-to group, thereby enhancing the novelty contrast between the jam and foil commercials for this group. This in turn implies that the foil commercials were more unfamiliar to the 111 competitor-loyal participants. Given the larger number of participants who selected the competitor jam (111 vs 18) we think it is unlikely that our selection of participants was so skewed that the foil commercials were unfamiliar to a majority of such a relatively large group.

We found the increased SST activity at the times of initial and final branding in the shift-to group only at the left lateral prefrontal site. Why this effect is restricted to the left hemisphere may have a number of explanations and we discuss these briefly. One possibility is suggested by the hemispheric encoding/retrieval asymmetry (HERA) model originally suggested by Tulving (Tulving *et al.* 1994). The HERA model proposes that the left frontal cortex plays a preferential role in encoding information into LTM, irrespective of whether or not it can be verbalised. By contrast the right prefrontal cortex plays a preferential role in the retrieval of information from LTM, irrespective of whether or not it is verbalised. In its original form, the HERA model was challenged by neuroimaging studies, pointing to the involvement of both left and right anterior frontal regions in LTM encoding. In particular, they reported that encoding of verbalised material preferentially elicited left prefrontal activity, while imagery that is not verbalised, such as unfamiliar faces, elicited corresponding right prefrontal activity (Kelley *et al.* 1998). A more recent formulation of the HERA model (Habib *et al.* 2003) suggests a reconciliation by proposing that both the HERA model and the preferential asymmetry in perceptual processing can coexist as independent processes – that is, the left hemisphere being predominantly responsible for encoding both verbal and non-verbal information, with the right hemisphere playing a predominant role for processing but not encoding to LTM visuo-spatial and non-verbal information. It should be noted that this issue is still the subject of some controversy, with a number of researchers continuing to report a specific role for the right prefrontal cortex for encoding into LTM non-verbal stimuli such as faces (see Sergerie *et al.* 2005).

Our findings of a strong left hemisphere bias in SST activity during the initial and final branding segments is consistent with the HERA model. The fact that initial and final branding segments featured text prominently (see Figures 1 and 3) is also consistent with the known specialisation of the left hemisphere for processing text information. Thus our observation of a strong left hemisphere bias during the initial and final branding segments could be accounted for by both mechanisms. Our observation of increased SST activity at both the left and right lateral prefrontal sites at the time of the key visual message in the advertisement – that is, the revelation of the 'secret' – is consistent with both the modified HERA model and the proposal that the right prefrontal cortex plays a role in LTM encoding of non-verbal information.

It is possible that non-text-based brand representation, such as image logos, may elicit right anterior frontal activity that is correlated with a change in brand preference, although our current experimental design does not allow us to examine this question.

While we believe the findings may be of interest to researchers concerned with the neuroscience of consumer choice, we suggest two important caveats. First, while our findings are consistent with the proposition that an advertisement can influence consumer brand preference only if the brand information is encoded in LTM, this does not mean that this is the only factor determining change to brand choice. Undoubtedly, other factors, such as sense of engagement and likeability, as well as the nature of the purchase, are all likely to play a role in influencing consumer brand preference. Thus we would suggest that LTM encoding of advertising brand information is a necessary but not sufficient condition to influence brand preference.

On a more general note, we have assumed that advertising-related changes in the activity of neural systems mediating brand preference, possibly the ventromedial prefrontal cortex, precede the encoding of brand information in LTM. In other words, changes of brand preference causally precede LTM brand encoding. However, our findings do not exclude the possibility that LTM brand encoding may precede or drive the change in brand preference. While our findings do not allow us to decide between these alternatives, both alternatives are consistent with our hypothesis that observed change in brand preference following advertising will be associated with LTM encoding of brand information during the advertisement.

The other caveat concerns the extent to which our specific left-hemisphere findings can be generalised to a wider range of television advertising and to both genders. Our study involved a relatively low-involvement consumer choice and a product-orientated television advertisement, and was also restricted to female participants. It is possible that the effectiveness of branding, as opposed to product advertisements for high-engagement products (such as cars), may be associated with increased SST activity during branding at both the left and right lateral prefrontal sites – particularly if the brand logo or symbol is a familiar image and is not text based. We think this may well be the case as a number of our unpublished television advertising commercial studies have revealed right prefrontal activity at times of branding for well-known pictorial or graphic (non-text) logos.

A final point to note concerns the specific advertising research opportunities available through the use of SST. One particular SST feature that warrants specific mention is the fact that the high SST signal-to-noise ratio means that multi-subject brain activity can be reliably assessed with as little as one trial or single ad exposure per participant. This is closer to the realistic viewing situation, where advertisements are rarely repeated in a block of advertisements. The capacity to assess television-viewing-related brain activity on the basis of a single trial means that it is also possible to examine the effect of multiple viewings of the same advertisement. Television advertisements are rarely presented only once, and it would be useful to see how memory encoding for different features of an advertisement changes with exposure repetition (Krugman 1972; Tellis 1997).

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