

How choice ambiguity modulates activity in brain areas representing brand preference: evidence from consumer neuroscience

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- *In the present paper we investigate whether choice ambiguity modulates activity in brain areas that represent brand preference and decision utility, as identified in previous studies. Our findings reveal that brain areas involved in the interaction of brand information and ambiguity information are the (predominantly left) ventromedial prefrontal cortex (VMPFC) and the anterior cingulate (AC). These activation patterns have earlier been found to correlate with brand preference. Thus, our findings show that the reduction of perceived ambiguity and information costs by brand information drives neural representations of brand preference as promoted by signaling theory in information economics.*

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Introduction

Previous research in marketing provides evidence that knowledge of the brand's name is an important product attribute, influencing consumers product perceptions and, through these their product preferences, their willingness to pay, consumption experiences, and pro-

duct loyalty (Allison and Uhl, 1964; Aaker, 1992; Keller, 1993; de Chernatony and McDonald, 1998). For example, a study from Allison and Uhl (1964) shows that consumers like the taste of a beer significantly more when they know the name of the beer brand, as compared to an anonymous tasting. The influence of brand name information on consumer choice seems to be particularly important in the case of product choices that are very similar with respect to their core attributes such as quality, price, and utilitarian value proposition. Other studies suggest that this is due to the signaling function of the brand name that triggers a variety of different

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Note: All figures will be produced in colour in the online published version.

associations like prior experiences with the brand, brand-quality inferences, and that reduces information asymmetry and information/search costs (Erdem and Swait, 1998).

Even more intriguingly, research in the nascent field of consumer neuroscience (Shiv *et al.*, 2005; Kenning and Plassmann, 2008; Lee *et al.*, 2007) indicates that brand preferences recruit specific brain systems during both choice tasks and the consumption experience. For example, a functional magnetic resonance imaging (fMRI) study by Deppe *et al.* (2005) showed that decision-making with prior brand preferences led to increased activity in brain regions involved in emotional and self-referential processing such as the ventromedial part of the prefrontal cortex (VMPFC) and the anterior cingulate cortex (ACC). In contrast, choices without prior preferences evoked increased activations of brain areas that are also activated during working memory tasks, introspection, and visual processing. Another fMRI study by McClure *et al.* (2004) shows that activity within the VMPFC correlates with prior preferences for colas during anonymous tasting. In addition, they found that the underlying mental process in the case when people know which cola brand they taste, as compared to uncertainty about which cola they taste, recruits memory areas of the brain such as the hippocampus and the dorsolateral prefrontal cortex (DLPFC). The authors suggest that subjects are retrieving their prior experiences with the brand during their consumption experience. In addition, a study involving patients with lesions in the VMPFC suggests that a lesion in the VMPFC, as compared to lesions in other areas of the brain and to healthy subjects, decreases the brand information bias on preference formation (Koenigs and Tranel, 2007). The commonalities of all these studies are the use of nearly identical products as stimuli and brand names as the main discriminative factor.

In the present paper we take these studies a step further by investigating the influence of ambiguity on the signaling power of brand information. Hence, we investigated whether (and, if yes, how) choice ambiguity modulates

activity in brain areas that were found to be involved in processing brand preference and decision utility, in accordance with previous studies [(i.e., the VMPFC and medial orbito-frontal cortex; Paulus and Frank, 2002; Erk *et al.*, 2002; Deppe *et al.*, 2005; Plassmann *et al.*, 2007)]. We scanned the brains of 15 subjects as they were making choices between nearly identical vacation packages (with only semantic differences in the description) to different destinations (low ambiguity: Germany's Black Forest, high ambiguity: Israel) offered by different travel operator brands (e.g., Thomas Cook vs. TUI). We found evidence for an increased preference signaling function of brand information in a high as compared to a low ambiguity context, accompanied by increased changes in neural activation changes in the VMPFC and the ACC.

The remainder of the paper is organized as follows. In the next section we will provide the conceptual background for our study that compares predictions based on signaling theory of information economics with those from branding theories rooted in cognitive psychology. Then we will describe our empirical study and conclude with a discussion of our results.

Conceptual background

Most branding theories are derived from cognitive psychology. They suggest that brand awareness, brand associations, and perceived quality lead to higher customer-based brand equity and, in turn, reduce perceived ambiguity (Aaker, 1992; Chaudhuri and Holbrook, 2001; Keller, 1993, 2002, 2003). These approaches predict that during choice under ambiguity the mere brand information triggers the modulation of neuronal activity in areas shown to represent brand preference such as the VMPFC (McClure *et al.*, 2004; Deppe *et al.*, 2005; Koenigs and Tranel, 2007).

Other theoretical approaches are based on signaling theory from information economics (e.g., Stigler, 1961; Stiglitz, 1989). They suggest that brand information serves as a signal of tangible (e.g., product quality) and intangible

(e.g., hedonic/social) utility that reduces asymmetrical information and then results in brand equity and preference (Erdem and Swait, 1998, 2004; Krishnan and Hartline, 2001). In other words, approaches from information economics propose that reduction of perceived ambiguity and information costs drives brand preference (Erdem and Swait, 1998, 2004). Thus, these approaches would predict that a reduction of asymmetric information due to an interaction of ambiguity and brand information signal would recruit brain areas involved in processing brand preference such as the VMPFC (McClure *et al.*, 2004; Deppe *et al.*, 2005; Koenigs and Tranel, 2007).

Against this background we tested the hypothesis that mere brand information can trigger activation found to represent brand preference during choice under ambiguity, as suggested by brand theories based on cognitive psychology (i.e., a main effect of brand information) against the alternative hypothesis that neural activation correlating with brand preference is triggered, instead, by the brand information and potential to reduce ambiguity (i.e., an interaction effect of brand information and high vs. low ambiguity), as promoted by signaling theory.

Empirical study

In order to investigate this hypothesis, we first conducted two pretests to select the stimulus material for the subsequent main study.

Pretests

In a first behavioral pretest we investigated whether brand information is an important service attribute when customers book a vacation package from a certain travel operator. In order to keep product attributes other than the brand information constant, the hypothetical offers consisted of nearly identical travel services that differed only in the wording of their description. In a two-staged experiment similar to anonymous taste tests of Coke versus Pepsi (de Chernatony and McDonald, 1998) we were able to show that as

compared to anonymous tasting (stage 1), the knowledge of brand information (stage 2) led to preference reversals (see **Figure 1 A**, $N = 25$).

We conclude that the factor “brand information” is important for travel service decisions and can be separated mentally from the service itself.

In a second pretest we tested whether ambiguity due to higher credence qualities of goods plays a role for travel services. As a measure for ambiguity we sampled ratings to which extend brand information can signal trust in a product category with low credence qualities (beer and coffee, fast moving consumer goods = FMCG) and compared it with brand trust ratings for travel services. Brand trust was assessed by a direct 5-point measurement scale (1 = very low trust, 5 = very high trust, $N = 35$). We employed a one-way analysis of variance (ANOVA) to compare brand trust ratings between these two product categories. We revealed that brand trust in the product category with low credence qualities is significantly lower ($M_{\text{BTrust_FMCG}} = 1.8$) than for travel services ($M_{\text{BTrust_Travel_Services}} = 4.0$, $F(1, 34) = 10.5$, $p < .005$). These findings support the position that ambiguity due to higher credence qualities plays a role for travel services.

Main study

Task and design

To investigate the impact of brand information signals on choices under ambiguity we scanned human subject brains ($N = 15$) using fMRI while the subjects made binary choices between 16 different travel operator brands. Subjects were instructed to choose the travel operator brand from which they would book a travel service to one of the two different destinations. For example, they could choose to book a vacation package to Germany’s Black Forest with TUI or Thomas Cook. The design enabled us to compare changes in brain activity in one experimental condition (e.g., no preferred brand for choice) as compared to

another experimental condition (e.g., preferred brand for choice) (the so-called subtraction method in neuroscience). No “resting” condition was implemented as a control condition to avoid the problem of ambiguous baseline conditions (Stark and Squire, 2001). This is in line with other similar studies in consumer neuroscience (e.g., Deppe *et al.*, 2005a, Deppe *et al.*, 2005b). In order to assess reproducibility and habituation effects, one session of 64 choice trials was presented four times to each participant (Lohmann *et al.*, 2004). Further, to avoid response-related brain activations and movement artifacts (Deppe *et al.*, 2005), the respondents were not asked for feedback during the fMRI data acquisition.

As a variation of Deppe *et al.*'s (2005) brand choice task, we added a second factor. We employed a two-factorial blocked design (factor 1: brand, levels = favorite (F), diverse (D); factor 2: ambiguity, levels = high (H), low (L)) resulting in four types of decisions in a pseudo-randomized order: (FD-H): the favorite brand versus various diverse brands and high-ambiguity context; (FD-L): the favorite brand versus various diverse brands and low-ambiguity context; (DD-H): diverse versus other diverse brands and high-ambiguity context; and (DD-L): diverse versus other diverse brands and low ambiguity context (see Figure 1B).

Subjects and stimuli

Fifteen healthy and right-handed subjects participated in the experiment (seven males, eight females, median age 24). All subjects met the requirements to participate in an fMRI study. Subjects were informed about the experiment and gave written consent before participating.

Based on the results of the pretests we selected stimuli from the travel service sector. We used 16 familiar travel operator brands to model the factor brand, and two different travel destinations that are generally perceived as either dangerous (high ambiguity) or not dangerous (low ambiguity) to model the factor ambiguity.

Data acquisition and preprocessing

All data were acquired from a 3.0 Tesla whole body scanner (Intera T30, Philips, Best, NL). For the acquisition of functional images blood oxygenation level dependent (BOLD) contrast images were acquired using a T2* weighted single shot gradient echo-planar imaging (EPI) sequence which covered nearly the whole brain. The data set consisted of 36 transversal slices of 3.6 mm thickness without gap that could be acquired with a TR of 3 seconds. The total acquisition time was 3 minute 20 seconds for each of the four runs. A T1-weighted structural image was also acquired for each subject. In combination with the fMRI measurement, while outside the scanner the participants were asked to rank the relevant travel operator brands according to their preferences outside the scanner.

The fMRI data analysis was performed using the Statistical Parametric Mapping software (SPM2; Wellcome Department of Imaging Neuroscience, London, UK; www.fil.ion.ucl.ac.uk/spm/). We applied the following preprocessing steps to the imaging data: (1) slice-timing correction (centered at TR/2); (2) realignment to the middle volume; (3) spatial normalization to a standard T2* template with a resampled voxel size of 3.6 mm³; (4) spatial smoothing using a Gaussian kernel with full width at half maximum of 8 mm; and (5) intensity normalization and high pass temporal filtering (filter width 128 s). The structural T1 images were co-registered to the mean functional EPI images for each subject and normalized using parameters derived from the EPI images.

Statistical analysis and results

We estimated a general linear model in which the exposure to each experimental condition was entered as a regressor of interest (Frackowiak *et al.*, 2004). These regressors, plus additional regressors of no interest were convolved with a canonical hemodynamic response function (HRF). We then calculated first-level single-subject contrasts to compare

Table 1. Results for the contrast [FD-H – FD-L] – [DD-H – DD-L], $p = 0.001(\text{corr.})$, $k = 5$ voxels

Cortical region	Side	BA*	<i>t</i> -value	MNI coordinates (<i>x</i> , <i>y</i> , <i>z</i>)
Frontal lobe, middle frontal gyrus	L	10	4.96	–14, 54, 0
Limbic lobe, anterior cingulate	R/L	24	n.s.	0, 36, 4
Limbic lobe, anterior cingulate	L	32	3.00	–14, 32, 25
Parietal/occipital lobe, precuneus	R	7/31	n. s.	14, –61, 29
Frontal lobe, superior frontal gyrus	R	10	n. s.	7, 58, –7

the choice between each individual subject's favorite brand (F) and a non-favorite brand (D) by ambiguity level (H = high, L = low). For these first-level contrasts we calculated two second-level group contrasts using a random-

effects model. This statistical approach of multi-level mixed-effects analysis is widely used in recent fMRI studies and it enables to make the intra- and inter-subject variability considerations (Frackowiak *et al.* 2004).

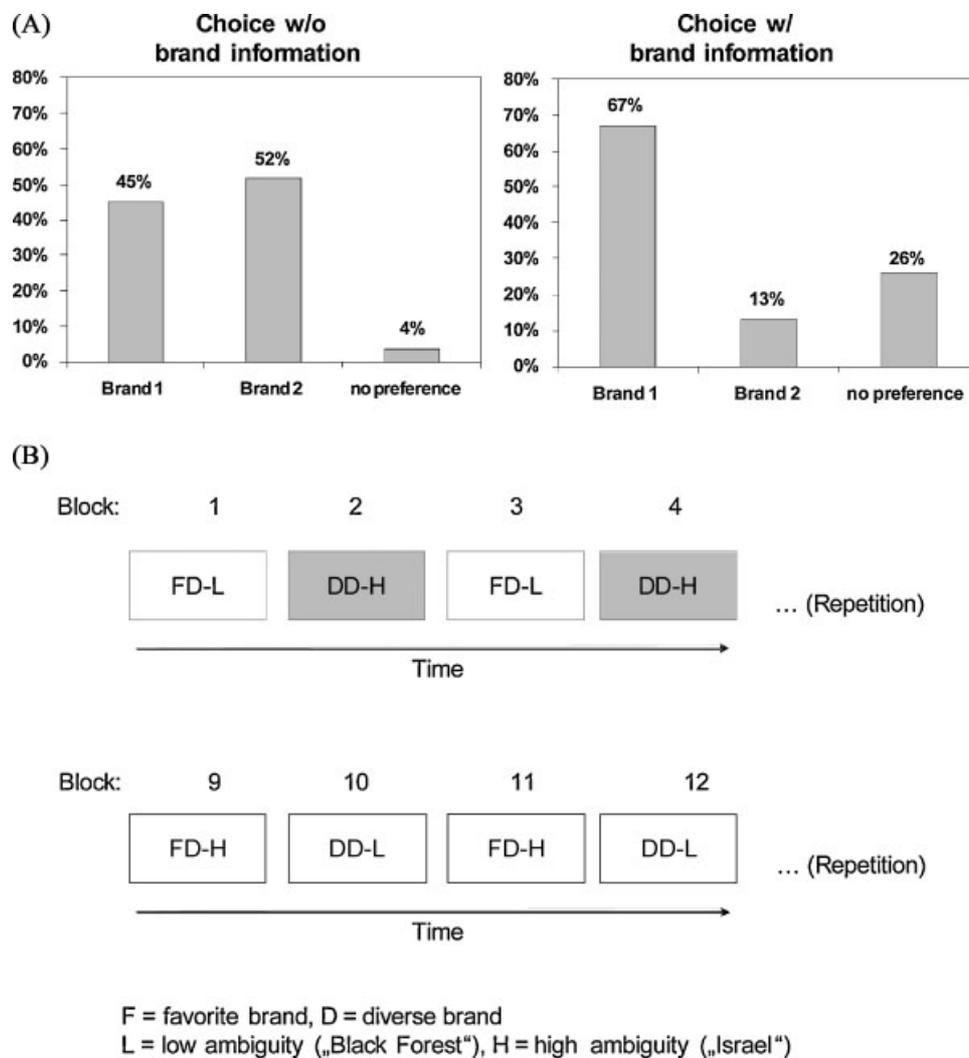


Figure 1. (A) Results of pretest choice of vacation package without and with brand information. (B) Experimental design main study.

First, we employed *t*-tests in a random effects model to analyze the main effect of the first factor (brand information, contrast [FD-H + FD-L] - [DD-H + DD-L]). The statistical data analysis did not result in any significant empirical evidence that the mere brand information triggered activation in brain areas representing brand preference signal.

Second, we employed *t*-tests in a random effects model to test for interaction effects between the factor brand information and the factor ambiguity (contrast [FD-H - FD-L] - [DD-H - DD-L]). We found significant interactions ($p < 0.0001$, corrected, minimum cluster size 10 voxels) reflected by activity changes within the left and right ventromedial prefrontal cortex (BA 10), the left anterior

cingulate (BA 32), and the right precuneus in the occipital/parietal lobe (BA 31) (see **Table 1** and **Figure 2**).

Discussion

The purpose of this study was to investigate the role of choice ambiguity for the neural representation of brand preference. Based on prior research, it was assumed that specific brand information acts as marker signals that correlate with activity changes in areas encoding brand preference such as the VMPFC (McClure *et al.*, 2004; Deppe *et al.*, 2005; Koenigs and Tranel, 2007).

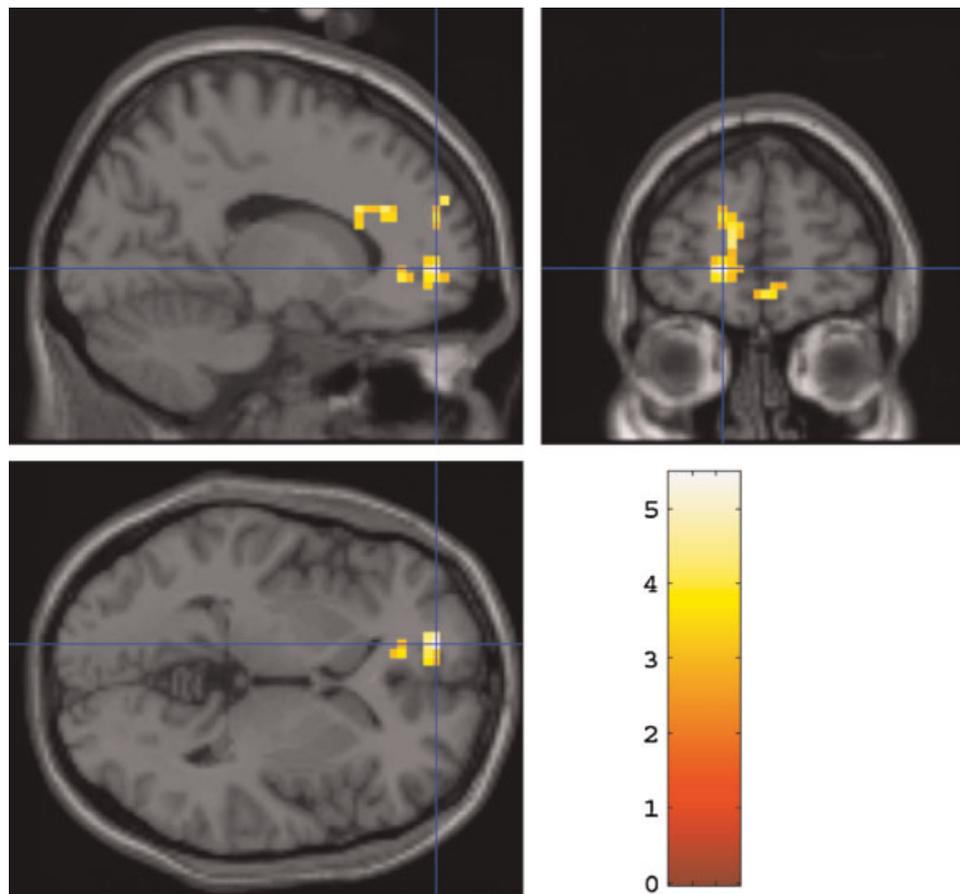


Figure 2. Activity in the VMPFC was higher for condition in the high versus low ambiguity context when the subject's favorite brand was present [FD-H - FD-L] than in the condition in the high versus low ambiguity context when the subject's favorite brand was absent [DD-H - DD-L]: Results for the contrast [FD-H - FD-L] - [DD-H - DD-L]. Activation maps are shown at a threshold of $p < 0.001$ corrected and with an extend threshold of 10 voxels. Scale encodes magnitude of *t*-values.

We found that mere brand information in a more complex choice context does not activate brain areas representing brand preference. This finding contradicts assumptions developed from cognitive psychology brand theories that would predict that, during choice under ambiguity, the mere brand information triggers the modulation of neuronal activity in areas in which activity changes were shown to correlate with brand preference, which in turn reduces perceived ambiguity. The present paper reveals that brain areas involved in the interaction of brand information and ambiguity information are the (predominantly left) ventromedial prefrontal cortex (VMPFC) and anterior cingulate (AC). These activation patterns have been found to correlate with brand preference (McClure *et al.*, 2004; Deppe *et al.*, 2005; Koenigs and Tranel, 2007). Our findings support the hypothesis from signaling theory that the reduction of perceived ambiguity and information costs by brand information drives neural representations of brand preference. Thus, the present findings bridge the gap between the two theoretical approaches in branding theory.

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Biographical notes

Hilke Plassmann is postdoctoral researcher in the Division of Humanities and Social Sciences of the California Institute of Technology, where she has been on the faculty since July 2006. Before that, she was a postdoctoral researcher in the Stanford Neuroeconomics Lab, Stanford University. She received a Ph.D. (Marketing and Neuroscience) from the University of Muenster's School of Business and Economics in 2005. Her primary research areas are consumer decision-making, self-control, and neuroeconomics. Her work has been published in various marketing and neuroscience journals and has been presented

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Peter Kenning is Professor of Marketing at Zeppelin University, Germany. His primary research interests are consumer behavior, consumer neuroscience, neuroeconomics, and marketing management. His work has been published widely, e.g., in *Management Decisions*, *Journal of Product and Brand Management*, and *Advances in Consumer Research*, as well as in the *Journal of Neuroimaging*, *NeuroReport*, and *Brain Research Bulletin*. He has presented papers at numerous conferences, including AMA, EMAC, and ACR. For his work he has received several best-paper awards and grants from the German government.

Michael Deppe is physicist (Ph.D.) and senior researcher in the Department of Neurology at the University of Muenster.

Harald Kugel is physicist (Ph.D.) and senior researcher in the Department of Clinical Radiology at the University of Muenster. His fields of research comprise advanced applications of magnetic resonance techniques, especially functional magnetic resonance imaging and magnetic resonance spectroscopy with a focus on normal and pathological brain function. He is author or co-author of more than 100 scientific papers.

Wolfram Schwandt is radiologist and post-doctoral researcher in the Department of Radiology, University Hospital Münster. After studying medicine in Münster he started his internship in internal medicine in Münster University Hospital. He wrote his doctoral thesis in the Institute of Physiology (epilepsy research). After the internship he spent one year as a postdoctoral fellow in the Department of Physiology and Neuroscience, NYU, New York and received further training as a postdoc in the Max-Planck-Institute for Neurological Research, Cologne, where he worked in stroke research and on the physiological mechanisms underlying functional brain activation. He came back to Münster in June 2001, where his main field of research is currently functional magnetic resonance imaging and diffusion tensor imaging.

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