HANG-YEE CHAN, MAARTEN BOKSEM, and ALE SMIDTS*

The authors demonstrate a novel template-based approach to profiling brand image using functional magnetic resonance imaging. They compare consumers' brain responses during passive viewing of visual templates (photos depicting various social scenarios) and brain responses during active visualizing of a brand's image, and then they generate individual neural profiles of brand image that correlate with the participant's own self-report perception of those consumer brands. In aggregate, these neural profiles of brand image are associated with perceived cobranding suitability and reflect brand image strength rated by a separate and bigger sample of consumers. This neural profiling approach offers a customizable tool for inspecting and comparing brand-specific mental associations, both across brands and across consumers. It also demonstrates the potential of using pattern analysis of neuroimaging data to study multisensory, nonverbal consumer knowledge and experience.

Keywords: consumer neuroscience, brand image, brand equity, functional magnetic resonance imaging, pattern analysis

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Neural Profiling of Brands: Mapping Brand Image in Consumers' Brains with Visual Templates

Communicating a brand's image clearly and effectively to consumers is crucial for building brand equity (Keller 1993, 2001; Park, Jaworski, and MacInnis 1986). Although brand image as a construct is nebulous and hard to define, it is generally understood as a broad set of mental associations consumers have in relation to a brand, through either exposure to marketing or prior interactions with the brand, during and after purchase (Aaker 1991; Brakus, Schmitt, and Zarantonello 2009; Herzog 1963; Keller 1993). Marketing researchers have stressed the importance of understanding how consumers form, organize, and access these mental associations with brands (Alba and Hutchinson 1987; Zaltman and Coulter 1995).

Instilling these mental associations with a brand in the consumer's mind is often achieved by deliberate marketing. In Keller's (2001) formulation of brand building, brand imagery involves "a fairly concrete initial articulation of user and usage imagery that, over time, leads to broader, more abstract brand association of personality" (p. 24). Such user and usage imagery fleshes out a situated moment that epitomizes the brand's desired and desirable image. For example, a cereal commercial on TV may feature a loving family around the breakfast table; a beer ad may depict a trendy partying crowd consuming the beverage. While these marketing efforts aim at reinforcing the associations between the brand and its desired user and usage imagery, how strongly and consistently these associations are forged in consumers' minds—and thus how effective such advertising is—is difficult to quantify and measure with self-report instruments.

In this article, we propose using a neuroimaging technique—namely, functional magnetic resonance imaging (fMRI)—to

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extract knowledge of brand image from consumers' brains through the process of visualization. Visualization is defined here as the conscious process of creating a visual representation for a brand, which consists of not only perceptual associations (visual features, images, and scenes) but also cognitive (intended user and usage) and affective (feelings and mood) information. We aimed to build neural profiles of brand image by comparing brain activation patterns during active visualization of brand image with those during passive viewing of a large set of naturalistic pictures as visual templates. This approach has the potential advantage of circumventing verbal articulation of what is essentially a visual experience.

BACKGROUND

Beyond Self-Report: Extracting Brand Information from the Consumer's Brain

There are existing self-report instruments that can be used to evaluate the transmission of brand image from marketing activities to the collective minds of consumers (Brakus, Schmitt, and Zarantonello 2009; Fournier 1998; John et al. 2006; Krishnan 1996; Low and Lamb 2000; Roth 1994). One of the most commonly used self-report instruments is the brand personality questionnaire (Aaker 1997), which provides a quick diagnostic of brand image based on a predefined set of personality attributes and has the advantage of being convenient to administer to a large group of consumers. Qualitative techniques, such as imagery elicitation (Roth 1994), structured interviews (Fournier 1998), laddering (Reynolds and Gutman 1988), and the Zaltman Metaphor Elicitation Technique (Coulter and Zaltman 1994), offer rich content for marketing insight based on individual in-depth reports. In between standardized diagnostics and qualitative reports are methodologies developed specifically for visualizing the mental association network, such as free association (Krishnan 1996) and concept mapping (John et al. 2006). Most of these self-report measures rely on translating one's mental associations into verbal description. Turning feelings and sensations into words inevitably requires a certain level of abstraction and simplification and may result in both loss of information and introduction of response artifacts in the process. This is especially pertinent in the context of brand communication, where much marketing activities take place in sensory pathways: visual, auditory, olfactory and tactile (Krishna 2012; Krishna and Schwarz 2014). In fact, the term "brand image" implies its predominantly visual nature, which is often transmitted through video and print advertisements. Asking consumers to verbalize their visual knowledge of brands entails a trade-off between manageability and depth; marketing researchers either rely on a set of predefined labels for quick comparisons or obtain insights from in-depth qualitative reports.

The use of neuroscientific methods in marketing studies promises new ways to gain access to consumers' minds without potential bias and limitation in self-report (Plassmann et al. 2015). In previous work on the neuroscience of branding, several studies have uncovered brain areas that exhibit differential reactions to brands with varying characteristics, such as familiarity, preference, and perceived status (for a comprehensive review, see Plassmann, Ramsøy, and Milosavljevic 2012). For example, a study comparing brain activations of brand and person judgments found that brand judgment involved particularly the left inferior prefrontal cortex, an area known to be involved in object processing, suggesting that brands may be perceived more like objects than people (Yoon et al. 2006). Brand familiarity is linked to memory-related neural pathways in the hippocampus and the frontal and temporal lobes (Esch et al. 2012; Klucharev, Smidts, and Fernández 2008), whereas interacting with preferred brands or luxury brands is associated with stronger activations in ventromedial prefrontal cortex and striatum, brain areas known for their role in reward processing (McClure et al. 2004; Plassmann et al. 2008; Schaefer and Rotte 2007). In summary, these studies provide good evidence that consumer knowledge of brands is in some way reliably represented by activity changes in particular brain areas. However, the most common analysis paradigm in the current literature involves categorical comparisons (e.g., familiar vs. unfamiliar brands), which are binary in nature and thus do not differentiate individual brands. Moreover, these studies are chiefly concerned with identifying anatomical regions in the brain associated with brand information processing, thus shedding light on the neural mechanism of such mental processes. However, exactly *what* brand information is represented in the brain is little studied. For example, are brands such as Disney and Apple—both widely known but with highly distinct images—uniquely represented in the brain? Moreover, do these differences in neural responses between brands and across individuals tell us about how these brands are perceived?

Decoding Brand Image Using Existing Brand Knowledge

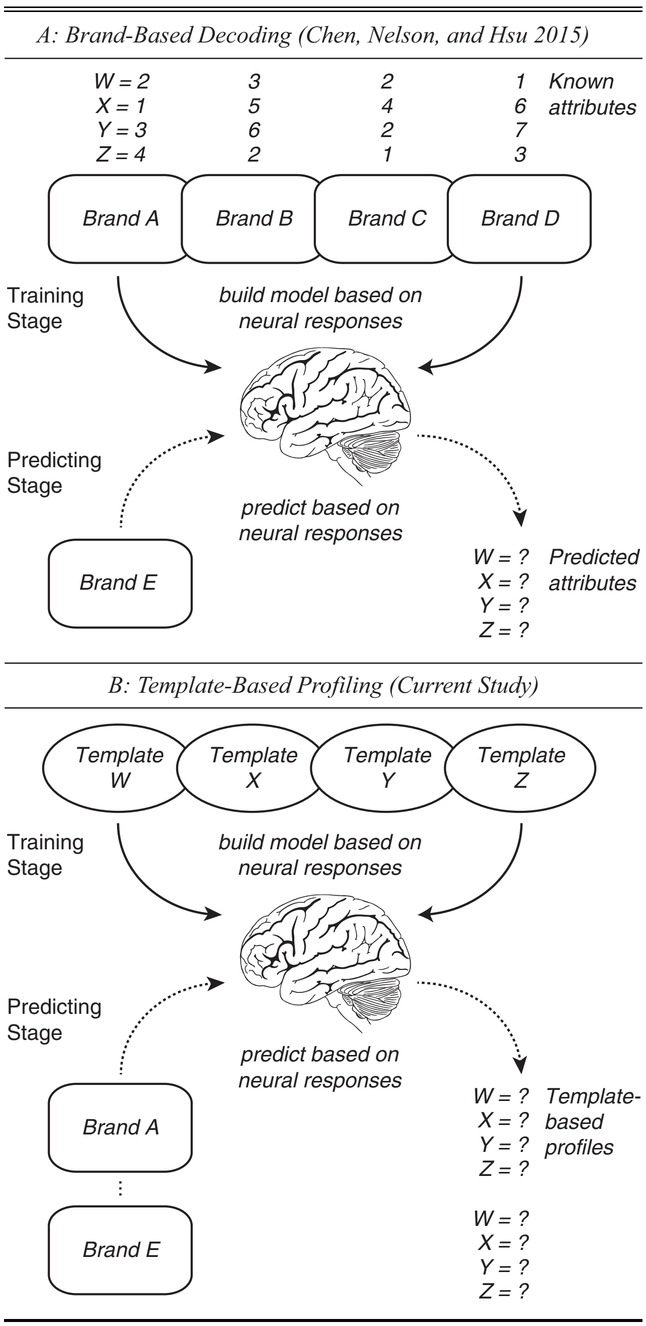
Recently, Chen, Nelson, and Hsu (2015) attempted to map neural response patterns onto multidimensional information of brand image. They started from the assumption that brands have a well-defined set of attributes uniformly perceived by consumers, thus forming the basis of their decoding model. They first obtained neural responses during passive viewing of a set of 44 well-known brands. Selecting Aaker's (1997) brand personality as the guiding model, which organizes brand information into five dimensions, the researchers were then able to fit existing brand personality profiles into a regression model described by a distributed network of brain activations. Specifically, they modeled the personality factor scores of 42 brands (training set) with brain responses during passive viewing of brand logos and then used the brain model to predict the personality factor scores of two remaining brands (testing set). By assuming the existence of a "ground truth" (i.e., brands have well-defined and universal personality profiles that exist independently outside the consumer's mind), the study demonstrated that this model-based approach can be useful in extracting brand information of an unknown brand from brain activities based on an external set of well-defined brands.

Neural decoding using existing knowledge of brands, while an invaluable addition to the marketer's toolbox, requires the assumption that brand perception is uniform across consumers. This might be problematic if some brands in the training sample change their personalities over time because of either endogenous (brand repositioning) or exogenous (change of market trends) forces, or when the testing population comes from a different demographic segment or culture than the training population and therefore may not share the same perceptions of brands.

In this article, we demonstrate an alternative approach to inferring mental content in consumers' brains by applying pattern analysis on neuroimaging data. We call this approach template-based profiling: instead of decoding brand image in consumers' brains with a priori knowledge of well-known brands, mental content is inferred by comparing neural responses evoked by brands with those evoked by a large set of naturalistic pictures as visual templates (for a schematic representation of the two approaches, see Figure 1, Panels A and B). There are two main assumptions behind the current effort: that (1) unique mental associations with brands can be represented by mental visualization and (2) mental images elicited during visualization are processed at least partly through the same neural pathways involved in viewing actual pictures. The first assumption rests on the fact that advertising is in most part communicated visually (Babin and Burns 1997; Henderson et al. 2003; Kirmani and Zeithaml 1993; LaBarbera, Weingard, and Yorkston 1998). It is therefore reasonable to assume that consumers form their brand knowledge through exposure to visual elements and that they should be able to retrieve such knowledge through active visual reconstruction of brand image. The second assumption finds empirical support in several neuroscientific studies that show considerable overlap in activated brain areas during visual perception and visual imagery (Chen et al. 1998; Kosslyn, Ganis, and Thompson 2001; Kosslyn and Thompson 2003; Roland and Gulyás 1994). Furthermore, neural representations evoked in visual perception and in visual imagery appear to share common features (Cichy, Heinzle, and Haynes 2012; O'Craven and Kanwisher 2000; Slotnick, Thompson, and Kosslyn 2005). For example, Horikawa et al. (2013) report that they were able to decode neural activity associated with visual imagery during sleep (i.e., dreams) by comparing these neural responses with those elicited by the viewing of various images during wakefulness.

Figure 1

OVERVIEW OF BRAND-BASED DECODING AND TEMPLATE-BASED PROFILING APPROACHES



STUDY 1: BUILDING INDIVIDUAL NEURAL PROFILES OF BRAND IMAGE

Overview of the Profiling Approach

The aim of Study 1 is to extract neural responses that represent a person's knowledge of brands and then validate our findings by comparing them with his or her self-report brand perception. Specifically, we first asked participants to engage in a visualization exercise involving brands, in which they tried to construct a mental picture that, in their opinion, best fit the brand's intended user and usage imagery and captured the "essence" of the brand image. We recorded neural activities as participants mentally formed those brand visual imageries (brand-imagery neural patterns). In the next step, participants viewed a series of naturalistic pictures depicting different social scenarios while their neural activities were recorded (picture-viewing neural patterns). The idea is to describe a brand's image in terms of its resemblance to various social scenarios, manifested in the participant's brain as similarities between brand-imagery neural patterns and picture-viewing neural patterns. In effect, the pictures depicting social scenarios collectively form a profiling space, based on which the content of brand image is inferred.

Determining the profiling space. Instead of selecting well-known brands as a training set as in Chen, Nelson, and Hsu (2015), the current approach requires a collection of templates that would serve as a profiling space. In this study we chose social context, in line with the observation that many advertisements showcase consumption in a social setting. For example, an analysis of 1,279 print advertisements from eight countries found that 26%–52% of them depicted more than one person (Cutler, Erdem, and Javalgi 1997). We further selected four contexts—familial, intimate, communal, and professional—that we believed would capture the different dimensions of social relationships according to sociological literature: kin versus nonkin, sexual-romantic versus non-sexual-romantic, cohabiting versus noncohabiting, hierarchical versus egalitarian (Blumstein and Kollock 1988). It is important to note that our choice of the social context images was not an attempt to comprehensively describe all aspects of brand image; rather, we believe the four social contexts provide an adequate profiling space that would be able to explain enough variance in the visual imageries participants would generate. In a supplementary analysis, we found supporting evidence that among a large set of consumer brands, consumers did report user and usage imageries that fit those four contexts, and these contexts could be used to differentiate brands (see Supplementary Analysis [S.A.] 1 in the Web Appendix).

Validating the model. To verify that this approach indeed extracted neural information of the individual's own brand knowledge, we considered two aspects: content and similarity. First, neural information extracted from the participant should be able to tell us how the (s)he thought about a particular brand. In the current study, we used visual templates from four different social contexts; for validation, we asked participants to rate the brands according to the same four categories. Thus, our first proposition was:

H_1: Brand-imagery neural patterns correspond with the individual's self-report perception of the brand's image.

In addition to content, we should be able to make use of neural information to map out a person's perception of brand similarity. Specifically, we adapted the paradigm used by Charest et al. (2014) and tested whether there was correspondence between neural and self-report brand similarity. To do so, we first obtained a neural measure of brand similarity by (1) creating a "neural profile" for each brand by comparing the brand-evoked neural pattern with each of the picture-induced neural patterns and then (2) measuring the similarity of neural profiles from different brands within an individual. We therefore tested the following hypothesis:

H_2: Brands that elicit similar neural profiles within an individual are perceived to be similar by that individual.

Method

We selected 14 well-known brands (see the Web Appendix) with diverse brand images from different product categories (electronics, apparel, personal care products, and software), such that brands in the same product category could have different images (e.g., Dell, Apple), while brands in different product categories could have a similar image (e.g., Axe, Durex). As visual templates, we used 112 pictures of naturalistic scenarios depicting various everyday situations, obtained from the Internet (for examples, see the Web Appendix; the whole set of pictures is available upon request). All of the pictures had neutral to positive valence, as we focused on positive brand images for the purpose of this study. These pictures fell into four social contexts (28 pictures each), showing professionally dressed people working in office settings (professional), intimate moments with romantic partner (intimate), family gatherings (familial), and partying with friends (communal).

We recruited 38 students (21 men; age range = 18–35 years, mean = 23.3 years, SD = 3.5) through our university's recruitment system. They received a fixed payment of €25 for their participation. We excluded 1 participant's data because of excessive head movements (>3 mm) while in the scanner, leaving 37 participants in the analysis. The study was approved by the local ethics committee, in line with the Declaration of Helsinki. All participants signed informed consent prior to participation and were given time (before entering the scanner) to construct mental images for each of the brands. Inside the scanner, they completed two tasks (for magnetic resonance data acquisition parameters, see the Web Appendix), after which they performed a brand similarity judgment task outside scanner. Approximately one week later, they completed an online questionnaire on brand perception.

Visual imagery formation prior to scanning. To evoke their visual imagery, participants were asked to read an instruction booklet containing the 14 brands. For each of these brands, participants reflected on its intended image and message and constructed a mental image depicting a typical social context associated with it (for the instructions, see the Web Appendix). Importantly, participants were completely free in the image they constructed; that is, they were not provided cues to form any particular image.

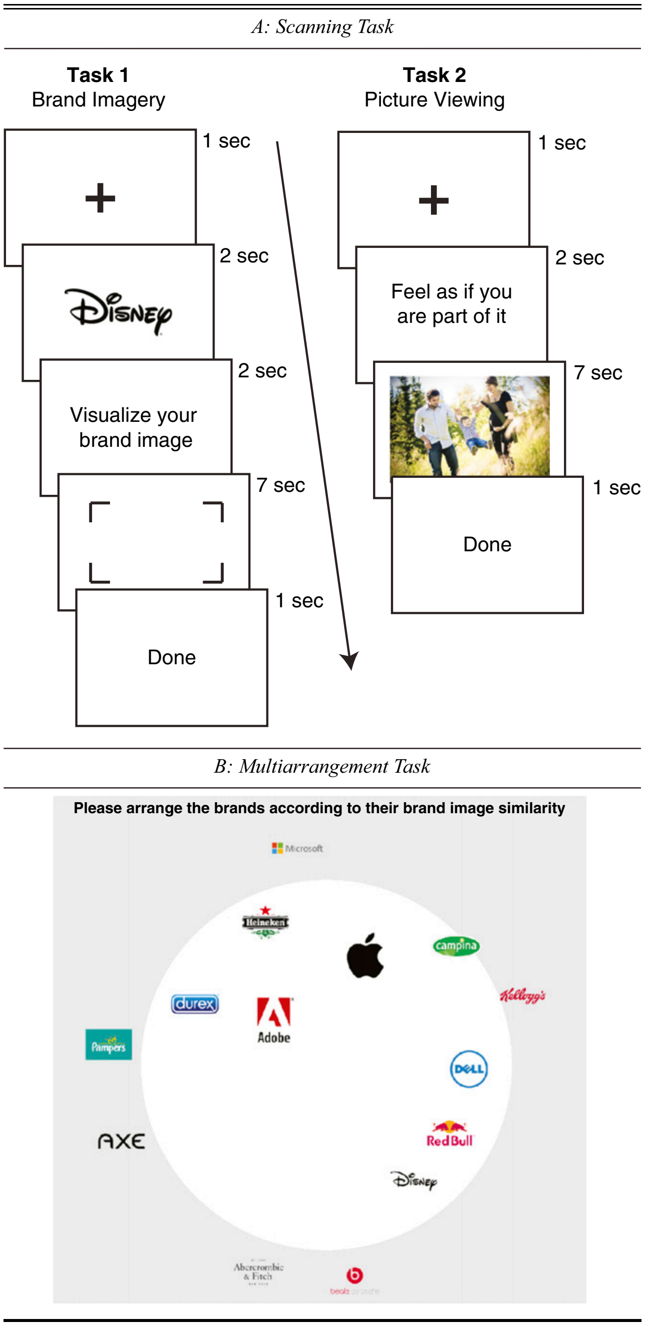
To ensure that participants understood the instructions, we had them first complete a practice brand (a well-known supermarket chain) in the presence of the experimenter, who answered questions they might have. The practice brand would not appear in the scanner task later. Then, they continued with the 14 brands at their own pace (i.e., without a time limit) and without interacting with the experimenter. The process took approximately 30–45 minutes. Afterward, participants were asked to practice in silence, for each brand, repeatedly reconstructing the images in their mind as vividly as possible, until they reported being able to recall all brands' images with ease. Although the experiment booklet instructed participants to describe the mental images in writing, the answers they gave were not analyzed in this study (examples are included in the Web Appendix).

Scanner tasks. There were two tasks that took place inside the scanner, separated by the acquisition of the structural (anatomical) scan (Figure 2, Panel A). The first task was brand imagery elicitation (brand imagery task), and the second task was the viewing of pictures depicting various social contexts (picture viewing task).

During the brand imagery task, participants were asked to recall the mental images they had constructed. Each trial began with a fixation cross, after which a brand logo was shown for 2 sec, followed by a recall cue (2 sec), a period in which subjects recalled the brand image (7 sec), and an end cue (1 sec). Between trials, there was a blank screen of varying length (1–3 sec). Within one block, the 14 brand logos were displayed in random order. The task consisted of six blocks separated by breaks (10 sec) and lasted about 22 minutes in total. In effect, each brand appeared six times.

During the picture viewing task, participants were asked to imagine themselves being in the settings depicted by the 112 pictures. Participants did not see the pictures or know the picture categories in advance. On each trial, a fixation cross (1 sec) was followed by a cue (2 sec), the picture (7 sec), and an end cue (1 sec). Between trials, there was a blank screen of varying length (1–3 sec). The 112 pictures were grouped in four blocks of 28 pictures (7 from each category), displayed in randomized order. The four blocks were separated by short breaks (10 sec). The task lasted about 27 minutes in total. In effect, each picture appeared only once.

Figure 2
PROCEDURE OF SCANNING TASK AND EXAMPLE SCREENSHOT OF MULTIPLE ARRANGEMENT TASK



Brand similarity. Immediately after scanning, participants evaluated similarities between brands in terms of brand image through the multiarrangement task (Kriegeskorte and Mur 2012), which is a more efficient alternative to pairwise comparisons. In this task, participants were asked to arrange the brands according to their similarity on a computer screen using drag-and-drop mouse operations, with similar brands placed closer together while dissimilar brands further from each other. (Figure 2, Panel B, shows an example screenshot during the task.) Participants were explicitly asked to judge similarity solely on the basis of brand image instead of criteria such as product category, perceived quality, and so on. The process began with the total set of 14 brands and subsequently repeated with subsets of brands adaptively selected at each round until a time limit was reached or the brand dissimilarity matrix was sufficiently stable. In a pilot test, we found that 15 minutes was sufficient time for this task of 14 brands. (For comparison, Mur et al. [2013] reported that it took typically one hour for participants to arrange 95 objects.) Using this method, each participant produced a 14 × 14 dissimilarity matrix, with each matrix element denoting the relative distance between a pair of two brands (the diagonal elements are always zeros).

Brand perception. About one week later, participants filled out an online questionnaire, in which they rated, for each of the 14 brands, how closely the brand fitted each of the four words: “work,” “lust,” “family,” and “party,” respectively. Under each word there was an unmarked visual analog scale (VAS) (range: −50 to 50) with labels “not fitting at all” and “a perfect fit” at opposing ends. The default position of the slider was set at the midpoint, and participants were required to move each slider at least once to indicate their response.

Neuroimaging Data Analysis

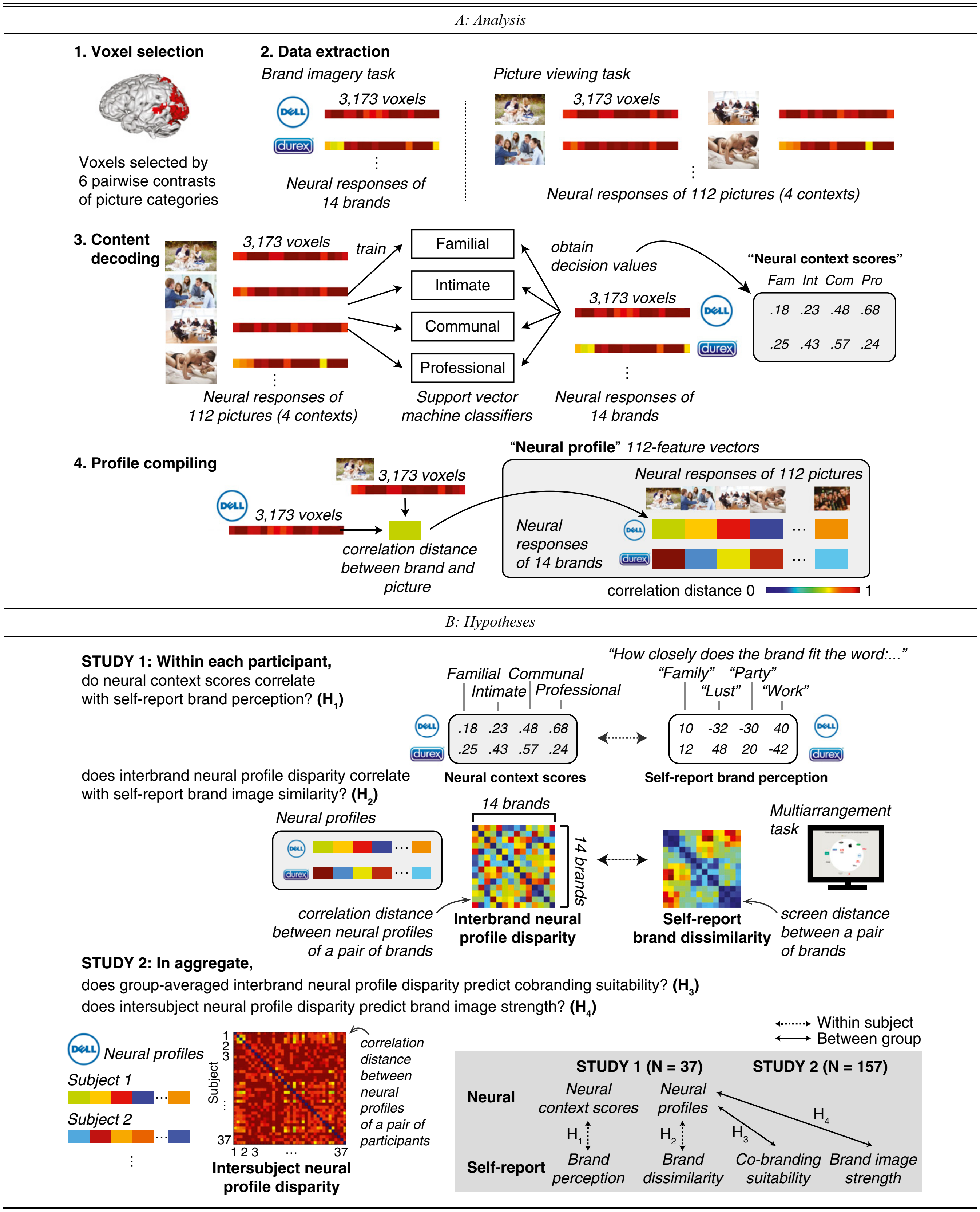
The neuroimaging data were preprocessed (for details, see the Web Appendix). The overall approach of the analysis is as follows (for an overview, see Figure 3, Panel A):

Voxel selection. To find voxels sensitive to social context across participants, we created for each subject a general linear model using picture categories as boxcar regressors to model neural responses during the seven seconds of picture viewing. Three regressors of noninterest (average white matter signal, average background signal, and screen luminance) were added to the model, together with a constant. Six contrasts, based on pairwise comparisons of the four social contexts, were created. These individual contrasts were entered into a random-effects group-level analysis. From each group-level contrast, we selected the top 1% voxels in each direction (i.e., voxels with contrast values below the 1st percentile or above the 99th percentile), and then the selected voxels from all six group-level contrasts were superimposed to form our region of interest (ROI) mask for data extraction for all participants. (Varying the threshold to .5% or 2.5% did not materially affect the results; see S.A. 2.)

Data extraction. Within each participant, we extracted the preprocessed neural data from both brand imagery and picture viewing tasks using the ROI mask. We performed linear detrending, regressing out average white matter and background signal, and voxel-wise z-scoring within each task’s data. For the picture viewing data, we extracted two consecutive volumes closest to the pictures’ onset time (0 sec and 2.3 sec, adding 6 sec to account for the hemodynamic response) and regressed out picture luminance at each time point. We then averaged them across the two time points and mean-subtracted them; in the end, we obtained 112 extracted volumes (neural responses to 112 pictures). The number of volumes was determined on the basis of its performance in classifying picture categories (S.A. 3).

For the brand imagery data, we selected three consecutive volumes (at 0 sec, 2.3 sec, and 4.6 sec, spanning in 6.9 sec in total) closest to the brand logos’ onset time (again adding 6 sec to account for hemodynamic delay). We chose the brand logo onset instead of the visualization phase onset (4 sec after brand logo onset) because participants reported that they began visualizing as soon as they saw the brand logo, even though

Figure 3
SCHEMATIC DIAGRAM OF THE ANALYSIS AND THE HYPOTHESES



we cued the participants to do so at the visualization phase. (Varying the number of volumes did not materially affect the results [S.A. 4], neither did using ROIs of different thresholds [S.A. 5].) We regressed out brand logo luminance separately at each time point, averaged these measures across the three time points, and mean-subtracted them. In the end, 84 extracted volumes (neural responses to 14 brands × 6 repetitions) were obtained.

Content decoding. Within participants, we trained four support vector machine classifiers on the picture viewing data, one for each social context (professional, intimate, familial, and communal). We then passed the brand imagery data to the classifiers and obtained four decision values (i.e., signed distances from the classification hyperplanes) for each of the 84 extracted volumes (14 brands × 6 repetitions), which were then averaged by brand. Each of the 14 brands therefore had four context scores ("neural context score"), each indicating the degree of pattern similarity of the brand to each of the four social context templates based on the participant's neural responses.

Profile compiling. Separately, within each participant, we calculated the correlation distances between the 84 extracted volumes (14 brands × 6 repetitions) in the brand imagery task and the 112 extracted volumes in the picture viewing task, resulting in an 84 × 112 matrix, which we then averaged by brand. Each of the 14 brands therefore had a 112-feature vector ("neural profile"), with each feature being the correlation distance to each picture. In effect, a brand's neural profile is a representation of a person's perception of that brand's image, expressed in the degrees of resemblance to the 112 template pictures. We used the neural profiles of brand image to compute two matrices (see "Study 1," Figure 3, Panel B): (1) an interbrand disparity matrix within each participant, which describes how neural profiles among brands are similar or different within a given participant, and (2) an intersubject disparity matrix within each brand, which describes how neural profiles among participants are similar or different within a given brand.

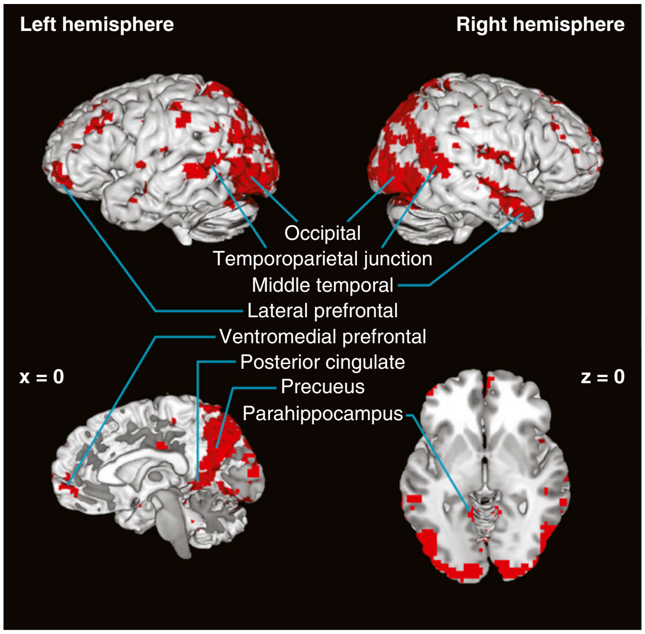
Identifying Brain Areas Associated with Social Context Processing

We identified a total number of 3,173 voxels (85.7cm^3) in the voxel selection process. (Brain areas with significantly different activation levels in pairwise social context contrasts are listed in Table S1 in the Web Appendix.) The resultant ROI mask covers several areas associated with visual processing, episodic memory, self-awareness, and the default network, including occipital cortex, precuneus, posterior cingulate cortex, parahippocampal gyrus, and temporoparietal junction (Figure 4).

To verify whether the selected voxels could indeed be used to reliably differentiate various social contexts, we performed a cross-validated classification test by linear support vector machine within each participant using the picture viewing data, with the four blocks as holdout folds. The average classification accuracy is 44.9% (SD = 8.2%), which is significantly above chance at 25% (t(36) = 14.6, $p < .0001$), indicating that the voxels contained information for social context decoding. This performance was roughly in line with the multicategory classification accuracy of complex stimuli in existing neural decoding literature, such as classifying natural scene pictures (31% with chance level at 16%; Walther et al. 2009), or emotional valence of speech (30% with chance level at 20%; Ethofer et al. 2009). Having established that our classifiers are able to distinguish between the different social contexts, we then proceeded to test our hypotheses.

Figure 4

BRAIN AREAS SELECTED FOR NEURAL DATA EXTRACTION



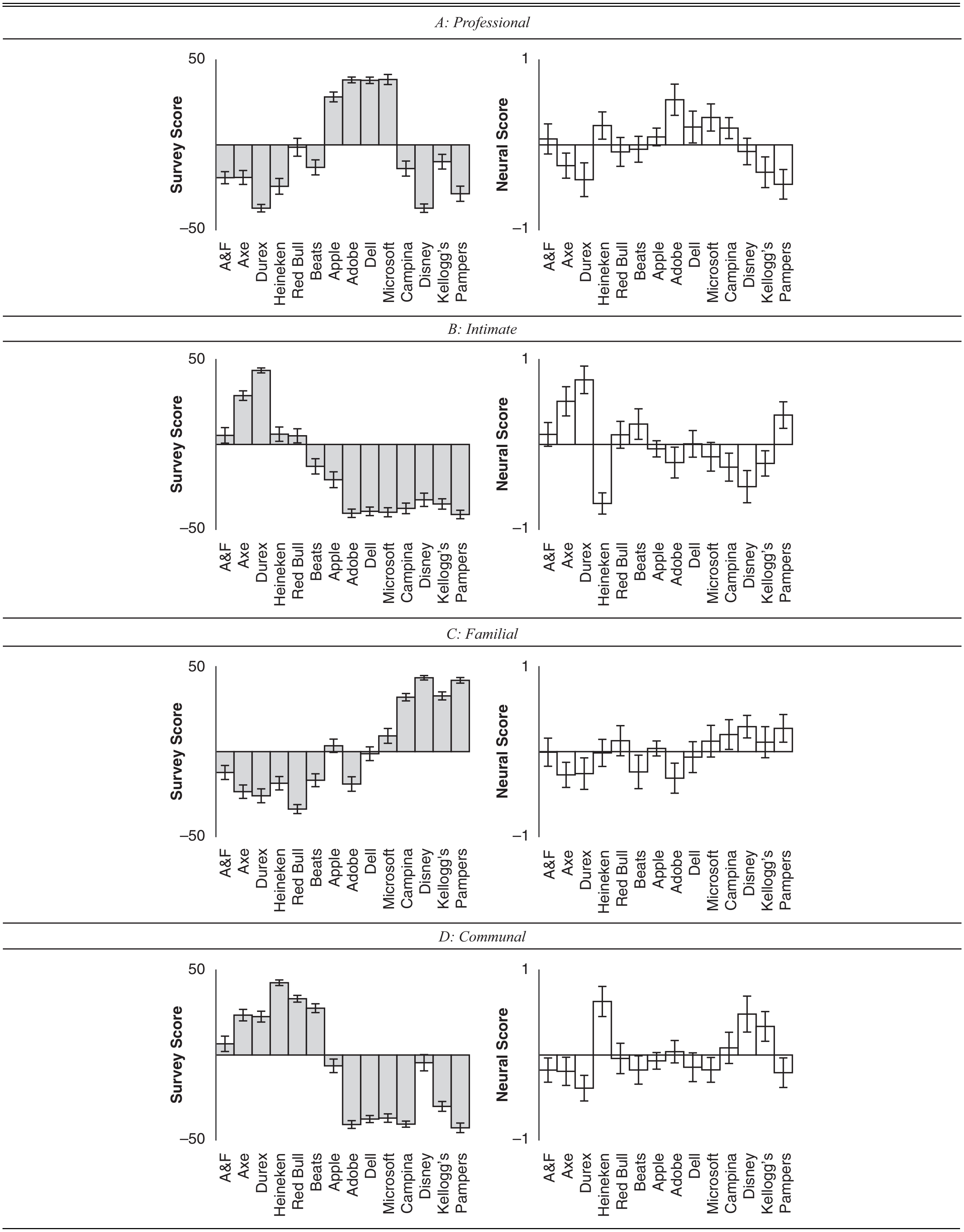
Notes: Voxels were selected from six contrasts using 1% thresholds in each direction, covering several areas associated with episodic memory, self-awareness, and the default network, including precuneus, posterior cingulate cortex, parahippocampal gyrus, and temporoparietal junction, in addition to lateral and ventromedial prefrontal cortices.

Neural Responses During Brand Imagery Correlate with Individual's Brand Perception

We passed the brand imagery data to these classifiers to obtain four decision values (i.e., signed distances from the classification hyperplanes) for each brand, representing the likelihood that the neural responses evoked by the brand imagery reflected the four different social contexts. Thus, each of the 14 brands received four context scores ("neural context score"), each indicating the degree of pattern similarity of the brand to each of the four social context templates based on the participant's neural responses (see Figure 5, right-hand panels).

We could then test how accurately the classifiers determined the visualized brand images in terms of these social contexts. We did so by comparing the neural context scores with the participants' responses in the follow-up brand perception survey, in which they indicated how they thought about a brand's intended social context (e.g., how much they thought the word "family" fit Disney; see Figure 5, left-hand panels). To test the extent to which the neural context scores corresponded with the self-report brand perceptions (H_1), we modeled participants' self-report brand perception with neural context scores using linear mixed-effects models with participants entered as random intercept both separately for each social context and together with all contexts (Table 1). Overall, neural context scores significantly correlated with survey responses (F(1, 1,501.28) = 15.7, $p < .0001$), meaning that when a participant's neural responses to a brand

Figure 5
SELF-REPORT BRAND PERCEPTIONS AND STANDARDIZED NEURAL CONTEXT SCORES



Notes: A&F = Abercrombie & Fitch; Beats = Beats by Dre; Campina = FrieslandCampina. Neural scores were z-scored individually and within category.

Table 1

LINEAR MIXED-EFFECTS MODELS (PARTICIPANTS AS RANDOM INTERCEPTS) OF SELF-REPORT BRAND PERCEPTIONS WITH STANDARDIZED NEURAL CONTEXT SCORES

	Model				
	1	*2*	*3*	*4*	*5*
Self-report brand perception	Professional	Intimate	Familial	Communal	Together
F-Statistics of Fixed Effects					
Neural score	6.1*	16.9***	4.4*	.6	15.7***
Context					22.1***
Neural score × Context					.7
Marginal R^2	.016	.042	.012	.002	.046
Coefficient for Each Context					
Professional	.185				.194
Intimate		.141			.104
Familial			.206		.196
Communal				.061	.062

*$p < .05$.
***$p < .001$.
Notes: In Models 1–4, we modeled context scores were modeled separately; we modeled them together in Model 5. Marginal R^2 is a measure of variance explained by fixed factors.

(e.g., Disney) during the imagery task resembled those during the viewing of similarly themed pictures (e.g., pictures depicting family gatherings), the participant also judged that brand to be more strongly associated with that particular context. In separate analyses, neural context scores significantly correlated with survey responses in three contexts (professional, intimate, and familial; *p*s < .05), while the coefficient for communal was not significant ($p = .43$). These findings confirm our first hypothesis and show that participants' perception of a brand's image can be captured by the decoded neural representation of social contexts for that brand.

Similarity of Neural Profiles Reflect Individual's Perceived Brand Similarity

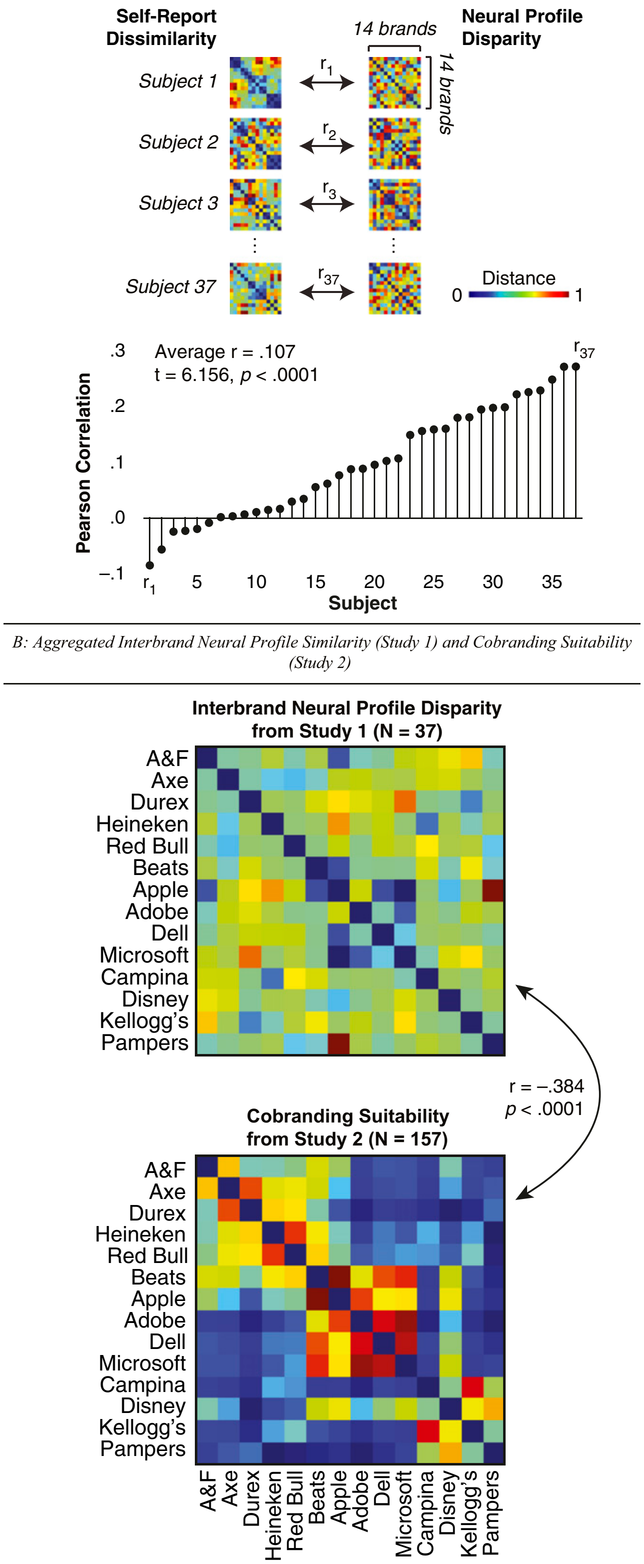
We investigated further whether individual neural profiles reflect idiosyncrasies in brand image perception. Following the analysis paradigm outlined by Kriegeskorte, Mur, and Bandettini (2008), we calculated for each participant a matrix of interbrand disparity between all pairs of the 14 brands, using the correlation distances of the 112-feature neural profiles. In addition, we obtained from participants their explicit judgment of brand image similarity from the multi-arrangement task (i.e., the subjective interbrand distances that formed a 14 × 14 dissimilarity matrix for each participant).

The question we would like to answer is whether neural profiles extracted from brain activities reflected the participant's own perceived brand similarity (H_2). We plot Pearson correlations between each participant's neural and self-report matrices in Figure 6, Panel A. The average correlation (after Fisher's r-to-z transformation; Silver and Dunlap 1987) was .107, and the Fisher-transformed correlations were significantly different from zero ($t(36) = 6.16$, $p < .0001$). That is, if a participant judged two brands to be highly different in

Figure 6

INDIVIDUAL AND AGGREGATED INTERBRAND NEURAL PROFILE DISPARITY

A: Individual Correlations Between Self-Report Brand Image Dissimilarity and Interbrand Neural Profile Disparity



Notes: In the plot in Panel A, correlations are sorted in ascending order. A&F = Abercrombie & Fitch; Beats = Beats by Dre; Campina = FrieslandCampina.

terms of brand image in the multiarrangement task, the neural activation patterns evoked by the two brands of that participant were also highly different. In contrast, when the participant judged two brands to be similar, the evoked neural responses during brand imagery also had similar patterns. This shows that neural profiles indeed captured the individual's perceived brand similarity, thus confirming our second hypothesis.

STUDY 2: MARKETING IMPLICATIONS OF NEURAL PROFILES

In Study 1, we were able to build neural profiles of brand images that reflected the individual's self-report perception of the brands. In addition to examining the relationship between individual neural responses and self-report brand perceptions, we reasoned that the aggregate neural responses of a group of consumers should offer information on brand image overall. We therefore investigated two possible implications: cobranding suitability and brand image strength (for an overview, see "Study 2," Figure 3, Panel B). Using the neural data collected in Study 1, we attempted to quantify the perceptual fit of brands, as rated by a larger external sample. This is especially relevant in cobranding (Blackett and Russell 2000), in which one product is branded by two independent brands (e.g., Betty Crocker cake mix and Hershey's chocolate), or advertising alliances (Samu, Krishnan, and Smith 1999), in which two brands enter into a partnership of joint promotion (e.g., GoPro camera and Red Bull energy drink). Previous studies have shown that for such a strategy to be successful, one of the determining factors is brand "fit," or consumers' perception of whether the partner brands are compatible in terms of brand concept or image (Helmig, Huber, and Leeflang 2008; Simonin and Ruth 1998; Van der Lans, Van den Bergh, and Dieleman 2014). Here, we posit that brands with similar neural profiles will be judged by consumers as suitable cobranding partners. We therefore propose,

> H_3: Similarity in neural profiles of brand image is positively associated with perceived suitability of cobranding.

Because we do not assume that people perceive brands the same way, we can obtain a measure of variation in brand image perception across individuals. This allows us to study consistency in brand image among consumers, which we refer to as "brand image strength." Although this concept has received scant attention in the literature, it has practical relevance to marketing practitioners. Intuitively, after exposure to effective marketing, different consumers should be able to form a similar set of mental associations with the brand; conversely, an ineffective brand-building exercise would leave consumers to draw their own idiosyncratic conclusions with regard to the brand's image. In other words, brand image strength should manifest itself not only in terms of image vividness within a consumer, but also in terms of image consistency across a group of consumers. A strong-image brand, in this sense, is one about which most consumers make a similar constellation of associations, whereas a weak-image brand is one that fails to instill similar images among consumers. Thus, our last hypothesis is that brands evaluated as having a stronger image should elicit more similar neural profiles across individuals. Therefore,

> H_4: Brands that elicit more similar neural profiles across individuals are perceived to have a stronger brand image.

Method

To obtain external ratings, we recruited 157 students (73 men; age range = 17–23 years, mean = 18.9 years, SD = 1.2) through our university's recruitment system. They received course credit for their completion of a 30-minute questionnaire, which consisted of two parts:

Cobranding suitability. Participants were shown a series of brand pairs drawn from the 14 brands. For each brand pair, they answered a self-constructed cobranding suitability measure, which consisted of three questions, each with an unmarked VAS slider (0–100): "Are these two brands a compatible fit?" (0 = "not fitting at all," and 100 = "a perfect fit"), "If the two brands decide to cosponsor an event (e.g., music festival, exhibition, tennis tournament, etc.), how natural would that feel to you?" (0 = "very unnatural," and 100 = "very natural"), and "If the two brands decide to develop a cobranded 'crossover' product, do you think it will more likely be a failure or a success?" (0 = "most likely failure," and 100 = "most likely success"). The default slider position was the midpoint, and participants were required to move each slider at least once. The cobranding suitability score of a given pair of brands is the average score of the three questions (Cronbach's $\alpha = .952$). Out of the possible 91 brand-pair combinations, each participant responded to a randomly selected subset of 45 pairs.

Brand image strength. In addition, they also completed the consumer-based brand equity scale (Yoo and Donthu 2001) for each of the 14 brands. This ten-item scale has three components: brand loyalty (three items), perceived quality (two items), and brand awareness/associations (five items). Of particular interest is the brand awareness/associations dimension, which consists of items related to brand image strength (example items are "I can recognize [brand] among other competing brands" and "Some characteristics of [brand] come to my mind quickly"). The wording of one item ("I can quickly recall the symbol or logo of [brand]") was changed to "I can quickly recall the advertisements or marketing materials" to better suit the purpose of this study. Participants responded to each item with an unmarked VAS slider (0–100), anchored at "strongly disagree" and "strongly agree." The default slider position was the midpoint, and participants were required to move each slider at least once.

Cobranding Suitability Is Associated with Interbrand Neural Profile Disparity

We examined whether, on an aggregate level, the neural profiles we obtained from Study 1 contain information about the characteristics of the brand's image that is representative of that segment of the consumer population (H_3). Note that raters in Study 2 were consumers of the same cultural background and similar age and gender distribution as in the Study 1 sample. They evaluated cobranding suitability among the same 14 brands; drawing on their responses, we generated a 14 × 14 cobranding suitability matrix, with each element being the average cobranding suitability score of a pair of brands (see Figure 3, Panel B).

Similarly, we averaged the interbrand neural profile disparity matrices of the participants in Study 1 and found the relationship between the aggregated interbrand neural profile disparity matrix and the cobranding suitability matrix to be significantly negative (Figure 6, Panel B; $r = -.384$, $p < .0001$).

This means that the more similar two brands' neural profiles are, the more suitable they are perceived by consumers as cobranding partners, confirming our third hypothesis.

Brand Image Strength Correlates with Neural Profile Consistency

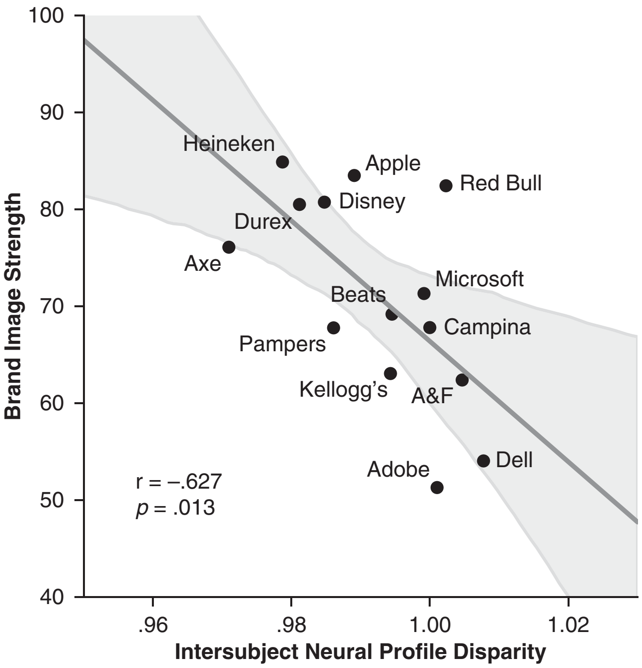
Finally, we investigated the possible link between brand image strength and neural profile consistency (H_4). We calculated neural profile consistency in the following way: for each brand, there were 37 neural profiles, one from each participant. Between every unique pair of participants (out of 666 possible combinations), the disparity of their neural profiles of the same brand (in terms of correlation distance) was calculated. We then took the average score of all intersubject neural profile disparities as an inverse measure of neural profile consistency.

Participants in Study 2 rated brand image strength drawing on their responses to the consumer-based brand equity scale. Exploratory factor analysis of the scale items suggested a two-factor structure, in which the first factor was the combination of brand loyalty (three items) and perceived quality (three items) subscales (Cronbach's $\alpha = .864$; this factor is named "brand attitude"), while the original brand association subscale (five items)—our measure of brand image strength—remained intact as the second factor (Cronbach's $\alpha = .834$).

Brand attitude did not significantly correlate with average intersubject neural profile disparity ($r = -.329$, $p = .255$, based on 10,000 random permutations of brands in calculating the intersubject disparity matrix; correlations with the original subscales, brand loyalty and perceived quality, were also not significant; $r = -.322$, $p = .266$; $r = -.301$, $p = .293$, respectively, based on permutations). In other words, neural profile consistency is not correlated with brand loyalty or perceived quality. However, the correlation between average intersubject neural profile disparity and brand image strength was significant (Figure 7; $r = -.627$, $p = .013$ based on permutations), meaning that brands that evoke more similar neural profiles across individuals indeed had a stronger brand image, thus confirming H_4.

Figure 7

INTERSUBJECT NEURAL PROFILE DISPARITY AND BRAND IMAGE STRENGTH



Notes: We calculated the *p*-value by Monte Carlo sampling of neural profiles (10,000 permutations). A&F = Abercrombie & Fitch; Beats = Beats by Dre; Campina = FrieslandCampina.

GENERAL DISCUSSION

An important component of consumer-based brand equity research is to understand the constellation of associations evoked by a brand in the consumer's mind (Aaker 1991; Keller 1993, 2003). Brand image, in this sense, is the meaningful organization of this associative memory network. While marketing researchers often emphasize the link between having a strong brand image and market success, and the advertiser's role in this link (Aaker and Biel 2013; Dahlén, Lange, and Smith 2010; Faircloth, Capella, and Alford 2001), assessing brand-building efforts has been difficult in part because there is no obvious reliable way to map out these mental associations in the consumer's mind. As a result, researchers often resort to indirect methods such as self-report questionnaires or qualitative interviews.

In this article, we examined brand image in the consumer's mind by extracting information directly from their brain during brand image visualization. Using a set of naturalistic pictures depicting various user and usage contexts as profiling space, we were able to build neural profiles of brand images that reflected the individual's self-report perception of the brands (Study 1). Moreover, in aggregate, the neural profiles were associated with cobranding suitability and offered a measure of brand image strength (Study 2). We thus provide a proof of concept of the neural approach in measuring brand image.

The current study extends previous neuroimaging studies on brand perception, notably by Yoon et al. (2006) and, more recently, Chen, Nelson, and Hsu (2015). In these two studies, participants rated whether an adjective suitably described a brand (in the former) or passively viewed brand logos and freely thought about them (in the latter). The current study used a cognitively more demanding task of visualization, in which participants needed to construct a mental image based on their perception of the brand. We found that brain areas sensitive to social context perception and involved in visual and emotional processing, episodic memory, and mentalizing, contained brand-specific information. These areas have significant overlap with the regions uncovered by Chen, Nelson, and Hsu in their passive brand perception task, including occipital and temporal regions, precuneus, hippocampus, and prefrontal areas. It shows that the active brand image visualization task applied in the current study at least partly shared the neural process of passive brand evaluation. More importantly, the current study extracted neural information from similar brain areas with a novel template-based profiling approach that (1) provided greater flexibility in organizing and measuring mental associations of brand image, (2) allowed individual variation in brand image, and (3) offered a potential measure of brand image strength.

Mapping Brand Associations by Neural Patterns

We found that neural profiles, created by comparing brain's responses to brands with the brain's responses to template pictures, describe an individual's brand image perception. Individual neural profiles also produce brand distance matrices that correlate well with how these participants report perceived similarities among brands. Our study adds to increasing efforts to capture idiosyncratic mental representations in the brain. Whereas previous studies investigated neural pattern similarity on the perception of objects (Charest et al. 2014), words (Bruffaerts et al. 2013) and body parts (Bracci, Caramazza, and Peelen 2015), the current study examined neural representational similarity in mental associations evoked by cultural artifacts (consumer brands), suggesting the potential of this methodology in understanding how complex human knowledge is represented in the brain. For marketing research, examining neural variability in brand image opens new avenues to study the evolution of brand image. In addition to brand repositioning programs (Simms and Trott 2007; Yakimova and Beverland 2005), studies have shown that brand image can change as a result of spillover effects during cobranding or brand alliance programs (Washburn, Till, and Priluck 2004). Our approach can be used to trace such dynamic updating of brand image and to learn how consumers acquire new mental associations as a result of marketing actions (Van Osselaer and Janiszewski 2001). This quantifiable measure can be used by marketers to evaluate the effectiveness of brand image messaging.

This study is, to the best of our knowledge, the first attempt to predict cobranding suitability using neural responses. Prior marketing literature on cobranding and brand alliance has emphasized the importance of perceptual fit (Gammoh, Voss, and Chakraborty 2006; Simonin and Ruth 1998; Thompson and Strutton 2013) in determining the success of such endeavors. In Smith and Park's (1992) formulation, perceptual fit includes aspects such as "product usage situations." Although there have been attempts to gauge these intangible aspects of perceptual fit through psychometric methods (e.g., Smith and Andrews 1995), the use of neuroimaging methods promises a new way to capture and quantify perceptual fit between brands.

Neural Reliability as Potential Quality Indicator of Consumer Experience

Finally, we found that the consistency with which a brand's image is neurally encoded across different consumers correlated with perceived brand image strength. There has been growing interest in understanding the implications of intersubject consistency in neural responses (Hasson, Malach, and Heeger 2010). Neuroimaging studies have shown that neural activities are often synchronized across people who process narratively rich stimuli, such as spoken stories (Silbert et al. 2014), speeches (Schmälzle et al. 2015), movies (Hasson, Malach, and Heeger 2010), and video clips (Nummenmaa et al. 2012). Moreover, the extent to which intersubject consistency occurs—commonly referred to as neural reliability—seems to be a measure of consumer engagement, in terms of viewership and ticket sales (Barnett and Cerf 2017; Dmochowski et al. 2014).

The current study extends this line of research in two ways. First, it demonstrates a novel application of neural reliability where the consumer experience in question is static. Neural reliability is most often measured in terms of *temporal* synchronization of a single voxel (time-series correlation) during dynamic stimuli processing (e.g., watching a TV show). The current study shows that *spatial* consistency across multiple voxels (spatial distance) during static stimuli processing (e.g., visualizing brand image) can also be a quality indicator—in this case, the image strength of a brand. Second, it further shows the feasibility of what we would term "meta-pattern" analysis. Instead of calculating pattern similarity by comparing raw neural signals across participants, we first calculated the feature vector of each stimulus on the basis of the relationships between its raw neural signals and those from the template set and then obtained a pattern similarity measure from those feature vectors. As such, measuring neural reliability using fMRI data no longer requires the assumption of strict one-to-one anatomical correspondence among individuals (i.e., given the same stimuli, each person employs exactly the same brain area in exactly the same way, despite evidence to the contrary; Barch et al. 2013). Indeed, in an exploratory analysis we used untransformed images in each participant's native brain space and created individually calibrated masks (i.e., selecting voxels using the participant's own contrast maps instead of the group's) and found that the findings were largely replicated (S.A. 6). Currently, it is unknown whether meta-pattern analysis is applicable in contexts other than visualization and whether such an approach offers additional insight over using raw neural signals. For example, instead of comparing voxel-wise time-series among viewers of a TV show, is it possible to first create a profiling space using a large set of emotional stimuli, then calculate moment-by-moment emotional feature vectors, and finally measure neural reliability on the basis of those vectors? Moreover, will this approach offer better predictive value by allowing individual differences in neural processing (Hamann and Canli 2004)? Further research is required to answer these questions.

Robustness Analysis and Study Limitations

We conducted a series of robustness analyses (detailed in the Web Appendix). We varied both the number of volumes and voxels extracted in the picture viewing task (S.A. 2 and 3) and in the brand imagery task (S.A. 4 and 5). We used untransformed brain images with individually calibrated masks (S.A. 6). We excluded voxels in visual cortex to determine whether brand-related information was confined to visual processing (S.A. 7). Instead of raw voxel data, we modeled brain responses in a general linear model first and used the estimated parameters (beta images) for analysis (S.A. 8). Finally, we recreated neural profiles with a subset of pictures (S.A. 9). Results were largely replicated in these robustness analyses. We also showed that neural profiles could be used to identify specific brands (S.A. 10); and neural responses appeared to be time-locked with the task (S.A. 11).

A fair question regarding the validity of the findings is to what extent the neural information we obtained from the task indeed uniquely captured brand image (as opposed to capturing, e.g., product category or quality). We believe that the current study does provide strong supportive evidence on this aspect. First, participants voluntarily spent approximately 30–45 minutes, at their own pace and without explicit time instruction, creating visual imagery for each of the brands (about 2–3 minutes per brand), indicating a high level of engagement on their part in the task. Second, the two separate self-report measures, one relating to categorical evaluation and the other relating to interbrand similarity, provide converging evidence that we were indeed measuring brand image. However, we acknowledge that the study was limited by the small number of brands. To better address this question, future research should include a larger number of brands while controlling for variation such as product category (e.g., using only car brands with diverse brand images).

It is not entirely clear whether the prescanner task was critical in evoking the neural responses to brands—that is, whether we would obtain similar results had the participants just seen the brand logos without the preparation task and without explicit instructions on visualization during scanning. We note that participants reported that they started visualizing at the onset of brand logo presentation, and that neural profiles appeared to be time-locked to the brand logo presentation (instead of the imagery phase 4 sec later; S.A. 11). Whether this is due to the extended practice during the preparation task or an indication of automatic processing remains to be answered. Further research is needed to determine the extent of automaticity of brand image processing.

We did not find a significant relationship between the neural score of the communal context ("party") and the corresponding self-report rating. There could be several reasons for this. First, in the questionnaire, participants were asked to rate how well the word "party" described the brands. It might well be that the term was overly vague and participants inferred a different meaning. (We note that the self-report rating took place one week after the scanning, and therefore, any direct recall of the pictures at that time should be minimal.) Second, pictures for the communal context mostly depicted people in a typical party scene with music and drinks. They might not sufficiently capture the variation in the actual mental images created by the participants. The potential lack of correspondence between the text label, the visual stimuli, and the mental images highlights another limitation of this study, which is that the quality of the profiling space was dependent on the choice of templates. Although our concern was mitigated by the finding that neural profiles were robust to using only subsets of the pictures without the communal context (S.A. 10), further replication efforts are needed to determine what visual stimuli should be included to represent the communal context.

Finally, we tested whether self-report data in Study 1 also predicted brand image strength and cobranding suitability in Study 2. For brand image strength, the intersubject reliability in self-report scores did not correlate with brand image strength (S.A. 12). Comparing the relative strength of neural and self-report data in predicting cobranding suitability (S.A. 13), we found that both neural and self-report data predicted cobranding suitability and that neural data did not explain additional variance beyond self-report data. This makes sense, because reporting on brand image similarity and cobranding suitability essentially answers a similar question. A more interesting question would be to what extent neural data can predict actual cobranding success in the market. However, at present we do not have such real-market data. Further research is required to determine the relative merits of self-report and neural data in predicting the success of such partnerships using real-world market outcomes (Venkatraman et al. 2015).

Template-Based Neural Profiling: Possible Directions for Future Application and Research

We believe that a big advantage of template-based neural profiling is that it offers great flexibility in choosing the relevant profiling space, such that it is best suited to a particular marketing question. Marketers can choose to focus on and study very specific associations that they believe to be crucial in the market in which they operate. As a result, future studies can extend this approach in several directions. First, other types of visual templates can be explored. For example, whereas we used pictures of different social contexts to decode user and usage imagery, pictures evoking various emotions can be used instead to produce an affect-based neural profile of brand image. One such candidate is the International Affective Picture System (Lang, Bradley, and Cuthbert 2008), which has the advantage of having well-validated valence and arousal scoring for each picture in the collection.

Second, whereas we chose pictures of predefined categories for profiling, it is possible to create a model-free profiling space instead by sampling naturally occurring stimuli without category-based selection. In one such example (Norman-Haignere, Kanwisher, and McDermott 2015), participants listened to 165 commonly heard natural sounds (e.g., door knocking, coughing) during fMRI scanning, and, based on these neural activations, the researchers found six sound-response components in the auditory cortex. A model-free profiling space might have the advantage of better capturing latent dimensions of neural response patterns and, therefore, producing neural profiles that better describe brand image.

Finally, this study has demonstrated the possibility of extracting knowledge from consumers without resorting to verbalization, potentially leading to new areas of academic and applied research on consumer experience. Neuroscientific research has helped reveal neural representations of sensory experience—not only sounds but also tastes (Smits et al. 2007), touch (Gallace and Spence 2009), smells (Lombion et al. 2009), as well as multimodal sensations (Barros-Loscertales et al. 2012; Castriota-Scanderbeg et al. 2005). With new methodological advances in neuroimaging research such as pattern analysis and machine learning, future research should capitalize on this rapid development to capture in richer detail consumer experience with products and brands, which is by nature multisensory and often defies verbal description (Smidts et al. 2014). By demonstrating a novel approach to capture consumers' visual representations of brand image, this study represents a first step toward understanding sensorial consumer knowledge and experience.

REFERENCES

Aaker, David A. (1991), *Managing Brand Equity: Capitalizing on the Value of a Brand Name*. New York: The Free Press.

Aaker, David A., and Alexander L. Biel (2013), *Brand Equity and Advertising: Advertising's Role in Building Strong Brands*. New York: Taylor and Francis.

Aaker, Jennifer (1997), "Dimensions of Brand Personality," *Journal of Marketing Research*, 34 (3), 347–56.

Alba, Joseph W., and J. Wesley Hutchinson (1987), "Dimensions of Consumer Expertise," *Journal of Consumer Research*, 13 (4), 411–54.

Babin, Laurie A., and Alvin C. Burns (1997), "Effects of Print Ad Pictures and Copy Containing Instructions to Imagine on Mental Imagery That Mediates Attitudes," *Journal of Advertising*, 26 (3), 33–44.

Barch, Deanna M., Gregory C. Burgess, Michael P. Harms, Steven E. Petersen, Bradley L. Schlaggar, Maurizio Corbetta, et al. (2013), "Function in the Human Connectome: Task-fMRI and Individual Differences in Behavior," *NeuroImage*, 80, 169–89.

Barnett, Samuel B., and Moran Cerf (2017), "A Ticket for Your Thoughts: Method for Predicting Content Recall and Sales Using

Neural Similarity of Moviegoers," *Journal of Consumer Research*, 44 (1), 160–81.

Barros-Loscertales, Alfonso, Julio González, Friedemann Pulvermüller, Noelia Ventura-Campos, Juan Carlos Bustamante, Víctor Costumero, et al. (2012), "Reading Salt Activates Gustatory Brain Regions: FMRI Evidence for Semantic Grounding in a Novel Sensory Modality," *Cerebral Cortex*, 22 (11), 2554–63.

Blackett, Tom, and Nick Russell (2000), "Co-branding—The Science of Alliance," *Journal of Brand Management*, 7 (3), 161–70.

Blumstein, Philip, and Peter Kollock (1988), "Personal Relationships," *Annual Review of Sociology*, 14 (1), 467–90.

Bracci, Stefania, Alfonso Caramazza, and Marius V. Peelen (2015), "Representational Similarity of Body Parts in Human Occipitotemporal Cortex," *Journal of Neuroscience*, 35 (38), 12977–85.

Brakus, J. Joško, Bernd H. Schmitt, and Lia Zarantonello (2009), "Brand Experience: What Is It? How Is It Measured? Does It Affect Loyalty?" *Journal of Marketing*, 73 (3), 52–68.

Bruffaerts, Rose, Patrick Dupont, Ronald Peeters, Simon De Deyne, Gerrit Storms, and Rik Vandenberghe (2013), "Similarity of fMRI Activity Patterns in Left Perirhinal Cortex Reflects Semantic Similarity Between Words," *Journal of Neuroscience*, 33 (47), 18597–607.

Castriota-Scanderbeg, Alessandro, Gisela E. Hagberg, Antonio Cerasa, Giorgia Committeri, Gaspare Galati, Fabiana Patria, et al. (2005), "The Appreciation of Wine by Sommeliers: A Functional Magnetic Resonance Study of Sensory Integration," *NeuroImage*, 25 (2), 570–78.

Charest, Ian, Rogier A. Kievit, Taylor W. Schmitz, Diana Deca, and Nikolaus Kriegeskorte (2014), "Unique Semantic Space in the Brain of Each Beholder Predicts Perceived Similarity," *Proceedings of the National Academy of Sciences of the United States of America*, 111 (40), 14565–70.

Chen, W., T. Kato, X.H. Zhu, S. Ogawa, D.W. Tank, and K. Ugurbil (1998), "Human Primary Visual Cortex and Lateral Geniculate Nucleus Activation During Visual Imagery," *Neuroreport*, 9 (16), 3669–74.

Chen, Yu-Ping, Leif D. Nelson, and Ming Hsu (2015), "From 'Where' to 'What': Distributed Representations of Brand Associations in the Human Brain," *Journal of Marketing Research*, 52 (4), 453–66.

Cichy, Radoslaw M., Jakob Heinzle, and John-Dylan Haynes (2012), "Imagery and Perception Share Cortical Representations of Content and Location," *Cerebral Cortex*, 22 (2), 372–80.

Coulter, Robin Higie, and Gerald Zaltman (1994), "Using the Zaltman Metaphor Elicitation Technique to Understand Brand Images," in *Advances in Consumer Research*, Vol. 22, Chris T. Allen and Deborah Roedder John, eds. Provo, UT: Association for Consumer Research, 501–07.

Cutler, Bob D., S. Altan Erdem, and Rajshekhar G. Javalgi (1997), "Advertiser's Relative Reliance on Collectivism-Individualism Appeals: A Cross-Cultural Study," *Journal of International Consumer Marketing*, 9 (3), 43–55.

Dahlén, Micael, Fredrik Lange, and Terry Smith (2010), *Marketing Communications: A Brand Narrative Approach*. Chichester, UK: John Wiley & Sons.

Dmochowski, Jacek P., Matthew A. Bezdek, Brian P. Abelson, John S. Johnson, Eric H. Schumacher, and Lucas C. Parra (2014), "Audience Preferences Are Predicted by Temporal Reliability of Neural Processing," *Nature Communications*, 5 (4567).

Esch, Franz-Rudolf, Thorsten Möll, Bernd Schmitt, Christian E. Elger, Carolin Neuhaus, and Bernd Weber (2012), "Brands on the Brain: Do Consumers Use Declarative Information or Experienced Emotions to Evaluate Brands?" *Journal of Consumer Psychology*, 22 (1), 75–85.

Ethofer, Thomas, Dimitri Van De Ville, Klaus Scherer, and Patrik Vuilleumier (2009), "Decoding of Emotional Information in Voice-Sensitive Cortices," *Current Biology*, 19 (12), 1028–33.

Faircloth, James B., Louis M. Capella, and Bruce L. Alford (2001), "The Effect of Brand Attitude and Brand Image on Brand Equity," *Journal of Marketing Theory and Practice*, 9 (3), 61–75.

Fournier, Susan (1998), "Consumers and Their Brands: Developing Relationship Theory in Consumer Research," *Journal of Consumer Research*, 24 (4), 343–53.

Gallace, Alberto, and Charles Spence (2009), "The Cognitive and Neural Correlates of Tactile Memory," *Psychological Bulletin*, 135 (3), 380–406.

Gammoh, Bashar S., Kevin E. Voss, and Goutam Chakraborty (2006), "Consumer Evaluation of Brand Alliance Signals," *Psychology and Marketing*, 23 (6), 465–86.

Hamann, Stephan, and Turhan Canli (2004), "Individual Differences in Emotion Processing," *Current Opinion in Neurobiology*, 14 (2), 233–38.

Hasson, Uri, Rafael Malach, and David J. Heeger (2010), "Reliability of Cortical Activity During Natural Stimulation," *Trends in Cognitive Sciences*, 14 (1), 40–48.

Helmig, Bernd, Jan-Alexander Huber, and Peter S.H. Leeflang (2008), "Co-Branding: The State of the Art," *Schmalenbach Business Review*, 60 (4), 359–77.

Henderson, Pamela W., Joseph A. Cote, Siew Meng Leong, and Bernd Schmitt (2003), "Building Strong Brands in Asia: Selecting the Visual Components of Image to Maximize Brand Strength," *International Journal of Research in Marketing*, 20 (4), 297–313.

Herzog, Herta (1963), "Behavioral Science Concepts for Analyzing the Consumer," in *Marketing and the Behavioral Sciences*. Boston: Allyn and Beacon, 76–86.

Horikawa, T., M. Tamaki, Y. Miyawaki, and Y. Kamitani (2013), "Neural Decoding of Visual Imagery During Sleep," *Science*, 340 (6132), 639–42.

John, Deborah Roedder, Barbara Loken, Kyeongheui Kim, and Alokparna Basu Monga (2006), "Brand Concept Maps: A Methodology for Identifying Brand Association Networks," *Journal of Marketing Research*, 43 (4), 549–63.

Keller, Kevin Lane (1993), "Conceptualizing, Measuring, and Managing Customer-Based Brand Equity," *Journal of Marketing*, 57 (1), 1–22.

Keller, Kevin Lane (2001), "Building Customer-Based Brand Equity: A Blueprint for Creating Strong Brands," *Journal of Marketing Communications*, 15 (2/3), 139–55.

Keller, Kevin Lane (2003), "Brand Synthesis: The Multidimensionality of Brand Knowledge," *Journal of Consumer Research*, 29 (4), 595–600.

Kirmani, Amna, and Valarie Zeithaml (1993), "Advertising, Perceived Quality, and Brand Image," in *Brand Equity & Advertising: Advertising's Role in Building Strong Brands*, David A. Aaker and Alexander L. Biel, eds. Hillsdale, NJ: Lawrence Erlbaum Associates, 143–62.

Klucharev, Vasily, Ale Smidts, and Guillén Fernández (2008), "Brain Mechanisms of Persuasion: How 'Expert Power' Modulates Memory and Attitudes," *Social Cognitive and Affective Neuroscience*, 3 (4), 353–66.

Kosslyn, Stephen M., Giorgio Ganis, and William L. Thompson (2001), "Neural Foundations of Imagery," *Nature Reviews Neuroscience*, 2 (9), 635–42.

Kosslyn, Stephen M., and William L. Thompson (2003), "When Is Early Visual Cortex Activated During Visual Mental Imagery?" *Psychological Bulletin*, 129 (5), 723–46.

Kriegeskorte, Nikolaus, and Marieke Mur (2012), "Inverse MDS: Inferring Dissimilarity Structure from Multiple Item Arrangements," *Frontiers in Psychology*, 3 (July), 245.

Kriegeskorte, Nikolaus, Marieke Mur, and Peter A. Bandettini (2008), "Representational Similarity Analysis: Connecting the Branches of Systems Neuroscience," *Frontiers in Systems Neuroscience*, 2 (November), 4.

Krishna, Aradhna (2012), "An Integrative Review of Sensory Marketing: Engaging the Senses to Affect Perception, Judgment and Behavior," *Journal of Consumer Psychology*, 22 (3), 332–51.

Krishna, Aradhna, and Norbert Schwarz (2014), "Sensory Marketing, Embodiment, and Grounded Cognition: A Review and Introduction," *Journal of Consumer Psychology*, 24 (2), 159–68.

Krishnan, H.S. (1996), "Characteristics of Memory Associations: A Consumer-Based Brand Equity Perspective," *International Journal of Research in Marketing*, 13 (4), 389–405.

LaBarbera, Priscilla A., Peter Weingard, and Eric A. Yorkston (1998), "Matching the Message to the Mind: Advertising Imagery and Consumer Processing Styles," *Journal of Advertising Research*, 38 (5), 29–42.

Lang, Peter J., Margaret M. Bradley, and Bruce N. Cuthbert (2008), "International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual," technical report A-8, Center for Research in Psychophysiology, University of Florida.

Lombion, Sandrine, Alexandre Comte, Laurent Tatu, Gérard Brand, Thierry Moulin, and Jean Louis Millot (2009), "Patterns of Cerebral Activation During Olfactory and Trigeminal Stimulations," *Human Brain Mapping*, 30 (3), 821–28.

Low, George S., and Charles W. Lamb (2000), "The Measurement and Dimensionality of Brand Associations," *Journal of Product and Brand Management*, 9 (6), 350–70.

McClure, Samuel M., Jian Li, Damon Tomlin, Kim S. Cypert, Latané M. Montague, and P. Read Montague (2004), "Neural Correlates of Behavioral Preference for Culturally Familiar Drinks," *Neuron*, 44 (2), 379–87.

Mur, Marieke, Mirjam Meys, Jerzy Bodurka, Rainer Goebel, Peter A. Bandettini, and Nikolaus Kriegeskorte (2013), "Human Object-Similarity Judgments Reflect and Transcend the Primate-IT Object Representation," *Frontiers in Psychology*, 4 (March), 128.

Norman-Haignere, Sam, Nancy G. Kanwisher, and Josh H. McDermott (2015), "Distinct Cortical Pathways for Music and Speech Revealed by Hypothesis-Free Voxel Decomposition," *Neuron*, 88 (6), 1281–96.

Nummenmaa, Lauri, Enrico Glerean, Mikko Viinikainen, I.P. Jaaskelainen, Riitta Hari, Mikko Sams, et al. (2012), "Emotions Promote Social Interaction by Synchronizing Brain Activity Across Individuals," *Proceedings of the National Academy of Sciences of the United States of America*, 109 (24), 9599–604.

O'Craven, K.M., and N. Kanwisher (2000), "Mental Imagery of Faces and Places Activates Corresponding Stimulus-Specific Brain Regions," *Journal of Cognitive Neuroscience*, 12 (6), 1013–23.

Van Osselaer, Stijn M.J., and Chris Janiszewski (2001), "Two Ways of Learning Brand Associations," *Journal of Consumer Research*, 28 (2), 202–23.

Park, C. Whan, Bernard J. Jaworski, and Deborah J. MacInnis (1986), "Strategic Brand Concept-Image Management," *Journal of Marketing*, 50 (4), 135–45.

Plassmann, Hilke, John O'Doherty, Baba Shiv, and Antonio Rangel (2008), "Marketing Actions Can Modulate Neural Representations of Experienced Pleasantness," *Proceedings of the National Academy of Sciences of the United States of America*, 105 (3), 1050–54.

Plassmann, Hilke, Thomas Zoëga Ramsøy, and Milica Milosavljevic (2012), "Branding the Brain: A Critical Review and Outlook," *Journal of Consumer Psychology*, 22 (1), 18–36.

Plassmann, Hilke, Vinod Venkatraman, Scott A. Huettel, and Carolyn Yoon (2015), "Consumer Neuroscience: Applications, Challenges, and Possible Solutions," *Journal of Marketing Research*, 52 (4), 427–35.

Reynolds, Thomas J., and Jonathan Gutman (1988), "Laddering Theory, Method, Analysis, and Interpretation," *Journal of Advertising Research*, 28 (1), 11–31.

Roland, P.E., and B. Gulyás (1994), "Visual Imagery and Visual Representation," *Trends in Neurosciences*, 17 (7), 281–87.

Roth, Martin S. (1994), "Innovations in Defining and Measuring Brand Image," in *Advances in Consumer Research*, Vol. 21, Chris T. Allen and Deborah Roedder John, eds. Provo, UT: Association for Consumer Research, 495.

Samu, Sridhar, H. Shanker Krishnan, and Robert E. Smith (1999), "Using Advertising Alliances for New Product Introduction: Interactions Between Product Complementarity and Promotional Strategies," *Journal of Marketing*, 63 (1), 57–74.

Schaefer, Michael and Michael Rotte (2007), "Favorite Brands as Cultural Objects Modulate Reward Circuit," *Neuroreport*, 18 (2), 141–45.

Schmälzle, Ralf, Frank E.K. Häcker, Christopher J. Honey, and Uri Hasson (2015), "Engaged Listeners: Shared Neural Processing of Powerful Political Speeches," *Social Cognitive and Affective Neuroscience*, 10 (8), 1137–43.

Silbert, Lauren J., Christopher J. Honey, Erez Simony, David Poeppel, and Uri Hasson (2014), "Coupled Neural Systems Underlie the Production and Comprehension of Naturalistic Narrative Speech," *Proceedings of the National Academy of Sciences of the United States of America*, 111 (43), E4687–96.

Silver, N. Clayton, and William P. Dunlap (1987), "Averaging Correlation Coefficients: Should Fisher's z Transformation Be Used?" *Journal of Applied Psychology*, 72 (1), 146–48.

Simms, C., and P. Trott (2007), "An Analysis of the Repositioning of the 'BMW Mini' Brand," *Journal of Product and Brand Management*, 16 (5), 297–309.

Simonin, Bernard L., and Julie A. Ruth (1998), "Is a Company Known by the Company It Keeps? Assessing the Spillover Effects of Brand Alliances on Consumer Brand Attitudes," *Journal of Marketing Research*, 35 (1), 30–42.

Slotnick, Scott D., William L. Thompson, and Stephen M. Kosslyn (2005), "Visual Mental Imagery Induces Retinotopically Organized Activation of Early Visual Areas," *Cerebral Cortex*, 15 (10), 1570–83.

Smidts, Ale, Ming Hsu, Alan G. Sanfey, Maarten A.S. Boksem, Richard B. Ebstein, Scott A. Huettel, et al. (2014), "Advancing Consumer Neuroscience," *Marketing Letters*, 25 (3), 257–67.

Smith, Daniel C., and Jonlee Andrews (1995), "Rethinking the Effect of Perceived Fit on Customers' Evaluations of New Products," *Journal of the Academy of Marketing Science*, 23 (1), 4–14.

Smith, Daniel C., and C. Whan Park (1992), "The Effects of Brand Extensions on Market Share and Advertising Efficiency," *Journal of Marketing Research*, 29 (3), 296–313.

Smits, Marion, Ronald R. Peeters, Paul van Hecke, and Stefan Sunaert (2007), "A 3 T Event-Related Functional Magnetic Resonance Imaging (fMRI) Study of Primary and Secondary Gustatory Cortex Localization Using Natural Tastants," *Neuroradiology*, 49 (1), 61–71.

Thompson, Kenneth, and David Strutton (2013), "Revisiting Perceptual Fit in Co-Branding Applications," *Journal of Product and Brand Management*, 21 (1), 15–25.

Van der Lans, Ralf, Bram Van den Bergh, and Evelien Dieleman (2014), "Partner Selection in Brand Alliances: An Empirical Investigation of the Drivers of Brand Fit," *Marketing Science*, 33 (4), 551–66.

Venkatraman, Vinod, Angelika Dimoka, Paul A. Pavlou, Khoi Vo, William Hampton, Bryan Bollinger, et al. (2015), "Predicting Advertising Success Beyond Traditional Measures: New Insights from Neurophysiological Methods and Market Response Modeling," *Journal of Marketing Research*, 52 (4), 436–52.

Walther, Dirk B., Eamon Caddigan, Fei-Fei Li, and Diane M. Beck (2009), "Natural Scene Categories Revealed in Distributed Patterns of Activity in the Human Brain," *Journal of Neuroscience*, 29 (34), 10573–81.

Washburn, Judith H., Brian D. Till, and Randi Priluck (2004), "Brand Alliance and Customer-Based Brand-Equity Effects," *Psychology and Marketing*, 21 (7), 487–508.

Yakimova, Raisa, and Michael Beverland (2005), "The Brand-Supportive Firm: An Exploration of Organisational Drivers of Brand Updating," *Journal of Brand Management*, 12 (6), 445–60.

Yoo, Boonghee, and Naveen Donthu (2001), "Developing and Validating a Multidimensional Consumer-Based Brand Equity Scale," *Journal of Business Research*, 52 (1), 1–14.

Yoon, Carolyn, Angela H. Gutchess, Fred Feinberg, and Thad A. Polk (2006), "A Functional Magnetic Resonance Imaging Study of Neural Dissociations Between Brand and Person Judgments," *Journal of Consumer Research*, 33 (1), 31–40.

Zaltman, G., and R.H. Coulter (1995), "Seeing the Voice of the Customer: Metaphor-Based Advertising Research," *Journal of Advertising Research*, 35 (4), 35–51.