Perceiving brands after logos perception: an event-related fMRI study

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Abstract

To investigate the cognitive processes that support the interpretation of brands' meanings, we recorded the brain function of human participants while they assessed real brands and also fictitious logos. Our aim was to contrast meaningful signs versus meaningless ones, as subjects could not rely on previous experiences or peers opinions about the new logos.

We found activation in a brain network that has been linked to meta-representational processes and self-relatedness. Based on these results and on a body of phenomenological literature on brands, we speculate that humans "do mind" with brands, i.e. brands are considered in a quasi-human level, as volitional actors moral-able.

This paradigm may inform better how brands behave and explain some "accidents" that brands have. In fact, they are not much different from the same accidents their progenitors (humans) suffer too: lack of perspicacity to understand the environment.

Keywords: brands, consumer behaviour, logos, meanings, neuroimaging.

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"[27] So Man created brand in his own image, in the image of Man he created him;"
(adapted from Genesis)

1. Introduction and Conceptual Development

In Peircean Semiotic there is the triadic relation among object, sign, and interpretant (Mick, 1986), the Thirdness. Brands are signs that convey objects' essence (anything humans can think about) through meanings, meanings that give rise to interpretations when they collide into a human mind. The way in such meanings are ascribed to brands has been the purpose of several studies. One source of meanings is the cultural milieu (McCracken, 1986) with its actors and the fashion system endorsing them to products, and ultimately induce brand imagery (Batra & Homer, 2004). However, the interpretation consumers make and their use of brands may reinforce assimilated meanings, or it may also produce new ones, which are thrown back to the milieu during brand usage in a co-creative fashion (Allen, Fournier, & Miller, 2008). Hence, the meanings of a brand are concerted in the social arena, there participating marketers and consumers, producing a semiotic system (Mick, Burroughs, Hetzel, & Brannen, 2004; Nöth, 1988). Although Nöth (1988) only finds a weak syntagmatic dimension in this semiotic system, maybe due to a systematic perseverance on marketers imprinting semantics into their brands creating differences towards their competition, i.e. insisting in the paradigmatic dimension, Kehret-Ward (1987, 1988) proposes the endowment of a syntax to consumers that, together with brands' semantics, make them able to produce purposeful complex narratives. In fact, the study of personal web pages reveals that individuals auto-involve with a paraphernalia of signs to publicly produce a discourse about themselves (Schau & Gilly, 2003), sustaining the notion of a core self supported by possessions (Ahuvia, 2005; Belk, 1988). The communicative role of apparel stresses the need for coherent discourses about the self through symbols and their meanings (Holman, 1981; Thompson & Haytko, 1997), which is also valid for product / brand avoidance (Banister & Hogg, 2004), which stresses the inherent syntagmatic dimension. In spite of this, not much research have been produced on the semiotic approach to brands (Mick, et al., 2004), and lesser on how persons interpret brands in their completeness, i.e. on the cognitive processes that subserve brands' meanings extraction and interpretation.

The work of Fournier (1998) revealed how consumers establish relationships with brands and how brands are important to structure their lives. These relationships are in fact special, and we claim that they are not only a suitable metaphor derived from human to human relationships. The interactions with nonhumans in the social plane have been the matter of recent investigations (Cerulo, 2009). Owens (2007) suggests that humans may entail direct interactions with non-biological objects, where objects are raised to the level of the actors, with volitional abilities. Brands may accomplish the four contingencies: initiate actions, threaten human actor's goals, these goals - e.g. self-concept - are critical to the actor, and finally, the actor needs to assimilate brands' meanings to help construct his/her self (Escalas, 2004). We claim then that humans "do mind" with brands, and to investigate how do humans relate with non-biologic brands and how do humans interpret brands' inherent meanings, we recorded brain function when human participants assessed real brands (meaningful signs) versus fake logos (meaningless "brands"), but that are perceived similar to the real ones.

2. Method

2.1 Experimental Design

To explore the research question, we designed an fMRI event-related experiment. There was four different events, plus the interstimuli interval. Each event was composed by thirty five slides, and each one was showed during 6.0 s. The interstimuli interval ranged from 4.0 until 9.0 s, in 0.5 s steps. The experiment duration was 1200 s, plus 9 s added in the end to guarantee the capture all of the hemodynamic response. The sequence was optimized with Optseq2 software (Athinoula A. Martinos Center for Biomedical Imaging, USA; http://surfer.nmr.mgh.harvard.edu/optseq/).

Three of the four events were brands' logos grouped in the following categories: positive, indifferent, and fictitious brands. The fourth event was non-emotional words, written in white over a black background. Along the interstimuli interval, subjects saw a fixation cross ("+" sign).

The selection of positive and indifferent brands is described in Supplementary materials. Fictitious brands were brands' logos that were created specifically for the present study. They do not exist at all in the market but they resembled current ones, so normal consumers could accept them as plausible.

The non-emotional words were determiners, conjunctions, prepositions or adverbs. Importantly, we did not use any nouns or verbs that could evoke emotions, objects or actions. In this event we hoped that the participants had a task to do, to focus his attention on it. By this way the participants were deviated from self-reflexive tasks (Beckmann & Smith, 2005; De Luca, Beckmann, De Stefano, Matthews, & Smith, 2006; Gusnard & Raichle, 2001), which tend to happen during passive tasks and that could cancel possible self-reflexive processes elicited by brands (Yoon, Gutchess, Feinberg, & Polk, 2006).

Depending on the event type, the participants were instructed to: rate the brand if a brand logo was being projected; read covertly (to avoid head movements) the word if a word was being projected; or just look to the cross if a fixation cross was being projected. As the reaction time was an important parameter to measure, the scale that subjects would use to rate the brands had to be simple and expedite, so the scaling had negligible interferences in the response. Due to this reason, our option was not to continue with the SAM and the PAD scale into the scanning session. We substituted it by a much simpler scale with four possibilities to rate brands: *positive*, *negative*, *indifferent*, or *unknown*. These same words appeared in the legend at the bottom of the projected image, every time a brand's logo was being projected. Slide sequencing, programming, and answers recording is described in Supplementary materials.

2.2 Image Analysis

FMRI data processing was carried out using FEAT (FMRI Expert Analysis Tool) version 5.98, a model-based GLM (General Linear Model) analysis tool, and also using PICA (Probabilistic Independent Component Analysis) as implemented in MELODIC (Multivariate Exploratory Linear Decomposition into Independent Components) version 3.09 (Beckmann & Smith, 2004), a model-free analysis tool, both part of FSL - FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl (S. M. Smith, et al., 2004; Woolrich, et al., 2009).

Participants did not maintain always the same ratings from the pre-scanning session for positive and indifferent brands, and some fictitious logos receive ratings other than unknown (see Supplementary Tab). To model all the situations and inherent cognitive processes, we considered 13 explanatory variables: 3 types of logos times 4 possible responses, plus the non-emotional words. At the individual level analysis the computed contrasts were positive versus fixation cross, non-emotional words, and unrecognised logos, indifferent versus fixation cross, non-emotional words, and unrecognised logos, and unrecognised logos versus fixation cross, and non-emotional words.

Group analysis was done with FLAME (FMRIB's Local Analysis of Mixed Effects) stage 1 and stage 2 with automatic outlier detection (Beckmann, Jenkinson, & Smith, 2003; Woolrich, 2008; Woolrich, Behrens, Beckmann, Jenkinson, & Smith, 2004). In this level, group means were calculated from the individual level contrasts. Z (Gaussianised T/F) statistic images were thresholded using clusters determined by $z > 2.3$ and a (corrected) cluster significance threshold of $p = 1.00$ (Worsley, 2001). Only clusters with more than 50 voxels survived the threshold.

As each participant's timecourse was different (because there was brands that did not maintain the same rating between the two sessions), in the MELODIC analysis, the eighteen data sets were concatenated and computed, aiming to extract independent spatial components. The following data pre-processing was applied: masking of non-brain voxels, voxel-wise de-meaning of the data, and normalisation of the voxel-wise variance. Pre-processed data were whitened and projected into a 164-dimensional subspace using probabilistic Principal Component Analysis where the number of dimensions was estimated using the Laplace approximation to the Bayesian evidence of the model order (Beckmann & Smith, 2004; Minka, 2000). The whitened observations were decomposed into sets of vectors, which describe signal variation across the temporal domain (time-courses), the session/subject domain and across the spatial domain (maps) by optimising for non-Gaussian spatial source distributions using a fixed-point iteration technique (Hyvarinen, 1999). Estimated component maps were divided by the standard deviation of the residual noise and thresholded by fitting a mixture model to the histogram of intensity values (Beckmann & Smith, 2004). The explanatory variable's basic shapes used in the FEAT analysis were concatenated for all the participants in the same order that timecourses entered MELODIC, and the same contrasts used in FEAT were computed. The parameter estimates of each spatial independent component were then calculated and tested using GLM. As this, the selection of significant spatial independent component was based on statistical criteria. For each independent component, additional GLM analysis was carried on with subjects to investigate to what extent the component was used among the group.

The identification of the main anatomical structures in the clusters was made with masks based on the statistical parametric maps produced by both analysis tools (GLM and model-free). The masks were designed according to the probabilistic atlases *Harvard-Oxford Cortical Structural Atlas* and *Harvard-Oxford Subcortical Structural Atlas* provided by the Harvard Centre for Morphometric Analysis (www.cma.mgh.harvard.edu), which are part of FSL View v3.0.2, part of FSL 4.1.2. Each voxel of each cluster was assigned to a single brain structure. In cases were several structures could be probabilistically attributed to a voxel, the structure that had the highest probability was chosen.

3. Results

Supplementary Table 1 contains the responses distribution according to the possible choices. Although all the 12 possible answers were modelled, only the Positive / Positive, Indifferent / Indifferent, and Fictitious / Unknown entered the final statistical analysis, because only these had enough data to make signal emerge from noise without extensive variation.

Figure 1 depicts the main brain regions that activated when contrasting meaningful brands versus fictitious logos, and serves as a key to interpret the activated brain regions in the following maps.

The brain slices depicted in Figure 2 illustrate the activated brain regions that resulted from the GLM analysis for the contrasts between real brands that maintained the same rate in both sessions (positive and indifferent) versus fictitious logos. The bottom line of this figure contains the conjunction analysis between these two contrasts.

The brain maps of Figure 3 represent the independent components (IC) that most significantly fit the modelled regressors positive and indifferent brands and negatively fit the regressor fictitious logos. The fit of IC 18 is $z = 12.01$ for positive > unknown, and $z = 17.92$ for indifferent > unknown, and the fit of IC 41 is, respectively, $z = 4.51$ and $z = 11.52$. The fit across the studied sample is $z = 4.99$ for IC 18, and $z = 3.71$ for IC 41.

Supplementary Table 2 lists the main brain structures that had more extensive activations in the conjunction analysis, and also in the two independent components that resulted from the model-free analysis.

To investigate further the differential role of selected regions during logos appraisal, the parameter estimates from the GLM analysis of the maximal foci are compared in the graphs of Figure 4 for the medial dorsal frontal pole, paracingulate gyrus, angular gyrus, and precuneous cortex. The maximum activation in the angular gyrus is close to the posterior supramarginal gyrus, and the same happens for the posterior cingulate gyrus and the precuneous cortex. The relative participation of all these brain structures is similar, being significantly superior for the recognised real brands (positive and indifferent) than for the fictitious logos.

4. Discussion

The cortical midline brain structures have been implicated in the resting-state (or default mode), which is largely recruited during self-reflexive processes (Beckmann & Smith, 2005; De Luca, et al., 2006; Gusnard & Raichle, 2001). These self-reflexive processes are a substantial part of social cognition (Iacoboni, et al., 2004; Schilbach, Eickhoff, Rotarska-Jagiela, Fink, & Vogeley, 2008) were each one monitors himself/herself by observing how the others act in response to own actions, a fact already pointed by Adam Smith that equals peers to looking-glasses (A. Smith, 1759, Part III, Chap. I, Of the Principle of Self-approbation and of Self-disapprobation):

> “We suppose ourselves the spectators of our own behaviour, and endeavour to imagine what effect it would, in this light, produce upon us. This is the only looking-glass by which we can, in some measure, with the eyes of other people, scrutinize the propriety of our own conduct.”

The fictitious logos used in this study were sawn by subjects by the first time in their lives, which means that subjects had not the opportunity to rely on previous experiences or benefit from the opinion of peers, to produce explicit assessments. They had similar appearance, mimicking real brands and their symbols. Thus, fictitious logos introduced a sharp confounding effect, eroding the symbolic vehicle so the intrinsic meaning of the brand could be achieved. When recognised brands (positive and indifferent) were contrasted to fictitious logos, brain structures that participate in meaning extracting were revealed, besides mere logos’ recognition and irrespective of logo’s valences. We focus on an activated network that encompasses the following cortical midline and parietal brain structures: frontal pole, paracingulate and cingulate gyri, precuneous cortex, angular gyrus, and posterior supramarginal gyrus.

In a meta-analysis, Amodio and Frith (2006) found that the medial prefrontal cortex could be divided into functionally different regions. They linked one of them, the anterior rostral medial frontal cortex (arMFC), to participations in self-knowledge, person perception, and mentalising tasks. We report repeated activations in the frontal pole significantly more for real brands and this region fits inside the arMFC. In another meta-analysis, Northoff et al. (2006) found a ventral cluster in the cortical midline structures that largely overlaps arMFC, to which they attribute a role in coding stimulus’ self-relatedness. D’Argembau et al. (2005) had also found correlations for the involvement of this brain region in self-referential tasks and resting, which was corroborated during direct and reflected self appraisals in the study of Ochsner et al. (2005).

The participation of the paracingulate gyrus in brands appraisal is considered in the framework of a mentalising process, although other possibilities may be deemed. The involvement of this region in theory of mind tasks is recurrent and several studies and reviews have been assigning a critical role to the paracingulate gyrus in meta-representations of mental states (second order representations), i.e. when individuals represent in their own brains the representations that they imagine other individuals have in their respective own brains, expressly their intentions, beliefs, and goals (Amodio & Frith, 2006; Frith, 2007; Frith & Frith, 2006; Gallagher & Frith, 2003; Rilling, Sanfey, Aronson, Nystrom, & Cohen, 2004; Saxe, 2006).

The precuneous cortex and the posterior cingulate gyrus form part of the posterior cluster to which Northoff et al. (2006) attribute a role in integrating stimuli in a temporal context, linking it to past self-referential experiences that comprise autobiographical memories. In fact, the review of Cavanna and Trimble (2006) suggests participations of the precuneous in episodic memory retrieval, self-related imagery, and first-person perspective taking. Other studies have been founding the activation of these brain regions in self-referential processes when contrasted with non-self stimulus (Kelley, et al., 2002; Ochsner, et al., 2005).

The angular gyrus and the posterior supramarginal gyrus integrate the temporo-parietal junction, another brain region that have been implicated in theory of mind tasks (Lindner, Hundhammer, Ciaramidaro, Linden, & Mussweiler, 2008; Saxe & Kanwisher, 2003; Saxe & Wexler, 2005), although it is a matter of debate (Mitchell, 2008) and response (Scholz, Triantafyllou, Whitfield-Gabrieli, Brown, & Saxe, 2009). Together with the paracingulate, these regions were proposed to support the understanding of social intentions (Ciaramidaro, et al., 2007), e.g. perceiving the social hierarchy (Chiao, et al., 2009; Zink, et al., 2008). With transcranial magnetic stimulation (TMS), the right temporo-parietal junction was found to support the sense of the own body (Tsakiris, Costantini, & Haggard, 2008), and with direct brain stimulation the same region evoked the will for conscious intentions (Desmurget, et al., 2009; Desmurget & Sirigu, 2009). It seems then that this brain region is involved in reading the intentions, beliefs and goals of others and differentiate them from own plans.

The activated network in the present study that encompasses the angular and posterior supramarginal gyri, the medial parietal cortex (precuneous), and the medial prefrontal cortex (frontal pole) is functionally interconnected (Lou, et al., 2004). Even more, these researchers proved causality towards self-relatedness using TMS. Analogous findings for the same network were reported by Jackson, Brunet, Meltzoff, and Decety (2006), emphasising the similarities and distinctiveness in representations of the self and other, which are crucial for empathy-based relationships. Still this same network was found to participate in group discrimination, favouring the in-group at the expenses of the others (Volz, Kessler, & von Cramon, 2009). It is possible then assign to this network a crucial role in social cognition, specifically in managing self-related issues, integrating with autobiographical memories and imagery, imagining the intentions, beliefs and goals of others, and in doing such, reflectively “scrutinize the propriety of our own conduct”.

The proposed involvement of brands in mentalising processes can be considered in two different planes. On one hand, brands have an important social role. They are central in promoting the formation of certain social groups and guaranteeing the respective cohesiveness and long-term duration (Cova & Cova, 2002; Moutinho, Dionísio, & Leal, 2007; Muniz Jr. & O'Guinn, 2001; Reingen, Foster, Brown, & Seidman, 1984; Veloutsou & Moutinho, 2009). Also, like possessions, they help individuals in their self-construal (Belk, 1988; Bhattacharya & Sen, 2003; Elliott & Wattanasuwan, 1998; Escalas & Bettman, 2005; Sirgy, 1982; Swaminathan, Page, & Gürhan-

Canli, 2007), and are even used to protect and repair the self (Sivanathan & Pettit, forthcoming). Ahuvia (2005) even stresses how "loved objects", including brands, structure social relationships. Possessions also contribute to social hierarchical categorisations (Dittmar, 1994; Dittmar & Pepper, 1994). Hence, there may be a "brands linking minds", or brands supported meta-representational processes in much of social relationships, at least when brands are present in the context. In this plane, as brands synthesise and provide much information about other individuals (Berger & Heath, 2007; Reed II, 2004), they also may trigger brain structures that support meta-representations.

In another plane, but not necessarily mutually excluded, the investigations of Fournier (1998) found that persons establish relationships with brands. Persons and brands, both (and it is important to emphasise both) contribute actively to the initiation, maintenance, and termination of the reciprocal relationship (Aaker, Fournier, & Brasel, 2004; Breivik & Thorbjørnsen, 2008; Fournier, 1998). The accomplishment or violation of the relationship norms, like in a human-to-human relationship, is used by individuals to make impressions about brands (Aggarwal, 2004; Aggarwal & Law, 2005), and the narratives that consumers draw involving brands with active roles help to tie connections tightly (Escalas, 2004; Kleine III, Kleine, & Kernan, 1993; Kleine, Kleine III, & Allen, 1995). Rindfleisch, Burroughs, and Wong (2009) claim that the materialistic linkages that individuals maintain with brands help to control own existential insecurity. Thus, brands are brought into a quasi-human level, and this level sanctions brands with emotional, thoughtful, and volitional abilities (Fournier, 1998), which means that it is possible to imagine the intentions, beliefs, and goals of brands, i.e. brands may be themselves the target of the meta-representational processes, and in such case, thinking on brands recruits the participation of the considered brain network.

At least in Western cultures brands help individuals construct, bent, maintain, and repair their self-concepts, inform about the social environment and there project their selves. Each brand has its own idiosyncrasy (Miller, 2007) that subjects assimilate and use to nourish their social self-concepts (O'Cass & Frost, 2002). Our results suggest that, conceptually, individuals do not think about brands as they think about trivial objects or animals, but in the same plane and using the same cognitive processes supported by the same brain networks, they think about their confederates, and in this sense, humans have a special cognition toward brands. Phenomena like the problems faced by some companies caught using child labour in their products' manufacturing suggest the existence of a moral dimension in brands, and this moral dimension may be the cause for the differentiation from objects, as it is the moral ability that humans recognised in their peers which makes them different from objects and animals (Adolphs, 2006). Morality is intrinsically connected to meta-representational processes (Stone, 2006), as it provides a framework to read and interpret the behaviour of others, humans and, we claim, brands too.

5. Limitations, Conclusions and Future Research

GLM analysis of fMRI data only provides correlations between BOLD (blood-oxygen level dependent) and paradigm manipulations, for each voxel individually. However, a multivariate analysis like PICA, reveals patterns of activity for multi-voxels, which may be specific to a particular task (Poldrack, 2008). In the present study we used both analysis, and we found similarities between then, which we interpreted as corroborations that bring robustness to the findings. Although the number of subjects (18) that participated in this experiment could be interpreted as scarce from the perspective of survey studies, it is acceptable in neuroimaging research and allow generalisation (Murphy & Garavan, 2004).

Some conditions of the method may limit the conclusions and have to be considered when interpreting the findings. The MRI scanner was inside a hospital and, although the research team had some precautions (e.g. not using common apparel of hospitals) the extent of this environmental influence is unknown. Subjects lay inside the MRI scanner for about 30 minutes without moving (with the exception of their fingers to record the decision), which is an uncommon position to appraise brands. This means also that the assessments made were explicit. Due to the spatial constrictions that the MRI scanner imposes and the prohibition of using current electric devices (due to magnetic interferences), and because we found important to record response time at this stage of the research, our option was for a simple four-button button-box optical device. Of course this limited considerably the response options. At the expense of not recording the response time, we are considering in using more elaborated scales (like PAD used in the pre-scanning session) in future studies.

In summary, the contrast between real brands and fake logos allowed the extraction of the intrinsic meanings of the former, and this process recruited a neural network that has been linked to self-relatedness, autobiographical memories, theory of mind, and meta-representations, i.e. all cognitive processes that humans use to accurately navigate in the social milieu and produce purposeful behavioural conducts. Conspicuously, this brain pattern was activated when subjects not face conspecifics, but brands' logos which, together with a wealth of phenomenological studies, raise brands from mere objects to a putative human-like level moral-able. This means that the relationships that humans maintain with brands may be more than a convenient metaphor. In fact, we claim that if the cognitive processes that subserve human-human and human-brand relationships are biologically the same, there will not have space for a distinction. These speculations are inferred from our findings and future studies should confront directly brands, objects, and persons.

Another issue that will be studied in a future experiment is the apparent contradiction with the results of the study of Yoon et al. (2006), where a semantic chasm was found between persons and products. This leads to questioning if the brand name is sufficient to transmit brand experience, as in the present study brands' logos were perceived in a much closer human trait level.

6. Managerial Implications

The immediate implications that this study may have for management are few if any. This is clearly an early basic science study, whose practical implications only tend to emerge in the long term.

However, an interesting perspective rises: whether humans directly mentalise about brands (i.e. guess their intentions, goals, and beliefs), whether humans perceive brands as a repository of human attributes and indirectly mentalise about other humans through brands, brands are interpreted as a human social construction. This provides a not so common environment for brands that marketers could explore in contributing to the construction of more human-like brands, as intrinsic socio-cultural elements that help defining self-identities (Elliott, 1994; Elliott & Wattanasuwan, 1998; Holt, 2002). So Man created brand in his own image, in the image of Man he created him...

7. References

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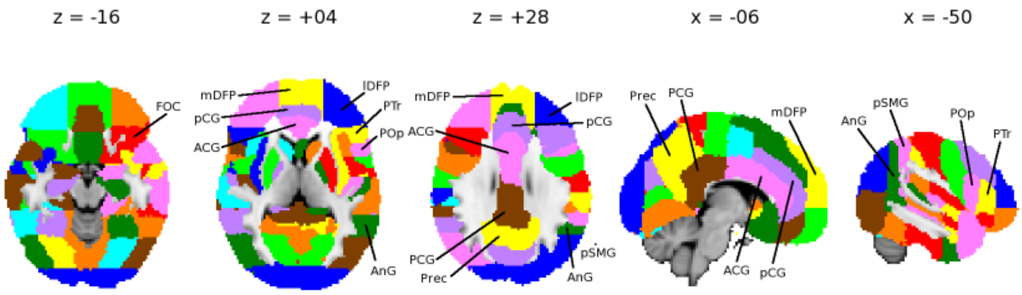

Figure 1 - Main brain structures that activated cumulatively in the contrasts positive > unrecognized logos and indifferent > unrecognized logos brands in the axial (z = -16, +04, and +28) and sagittal (x = -06, and -50) planes. AnG - angular gyrus; ACG - anterior cingulate gyrus; pCG - paracingulate gyrus; lDFP - left dorsal frontal pole; mDFP - medial dorsal frontal pole; FOC - frontal orbital cortex; PCG - posterior cingulate gyrus; POp - pars opercularis; Prec - precuneous; PTr - pars triangularis; pSMG - posterior supramarginal gyrus; Radiological convention; MNI152 coordinates.

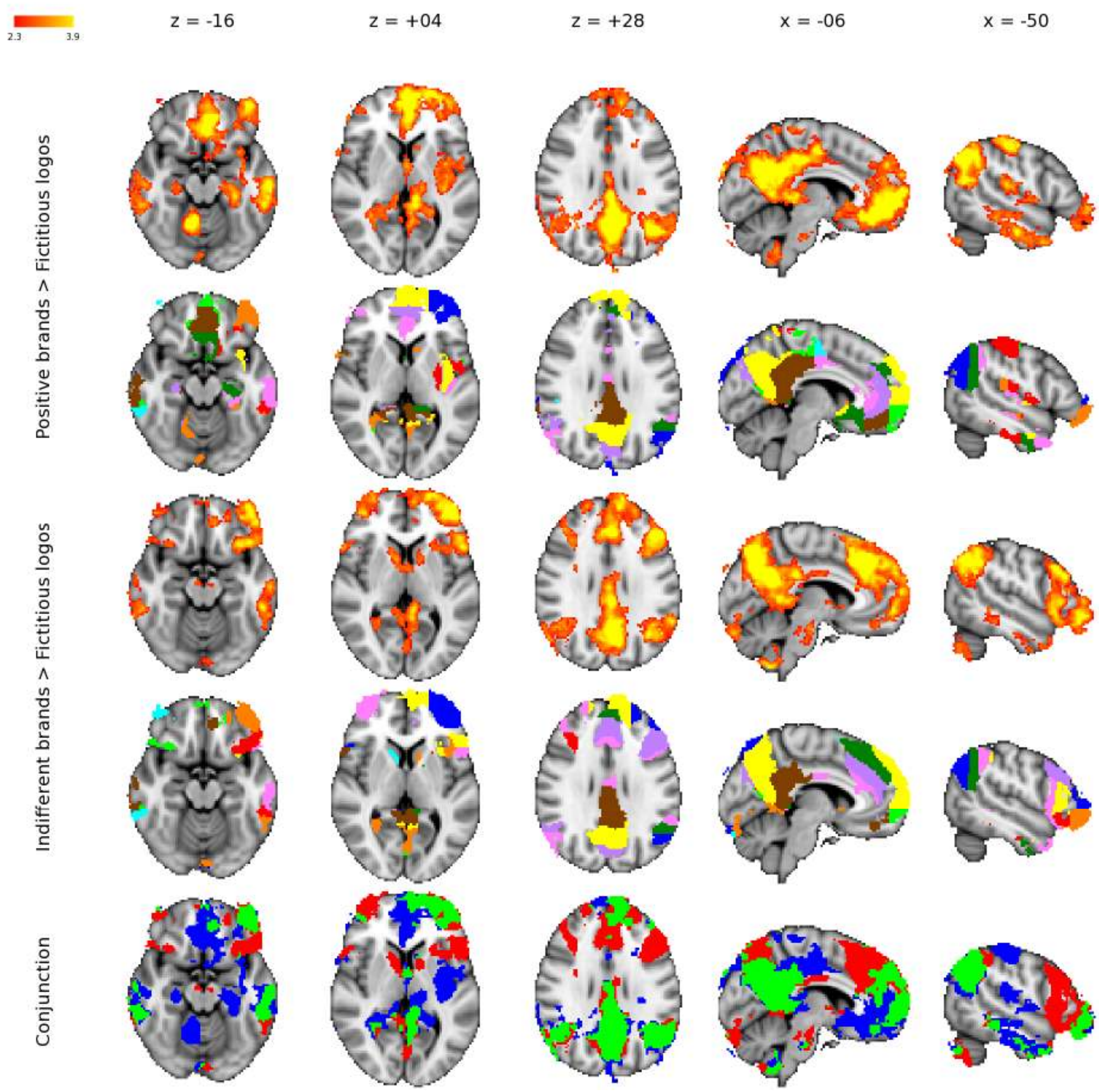

Figure 2 - FMRI maps for the contrasts between recognized real brands (positive and indifferent) versus fictitious logos, and the respective conjunction analysis in the axial (z = -16, +04, and +28) and sagittal (x = -06, and -50) planes (statistical parametric maps produced by FEAT). For each contrast the first row refers to the thresholded maps (z > 2.3), and in the second row the brain regions are individualised with different colours (see key in Figure 1). In the conjunction analysis row, common voxels are in green colour, voxels that activate only for the contrast positive versus fictitious logos are in blue, and voxels that activate only for the contrast indifferent versus fictitious logos are in red. Radiological convention. MNI152 coordinates.

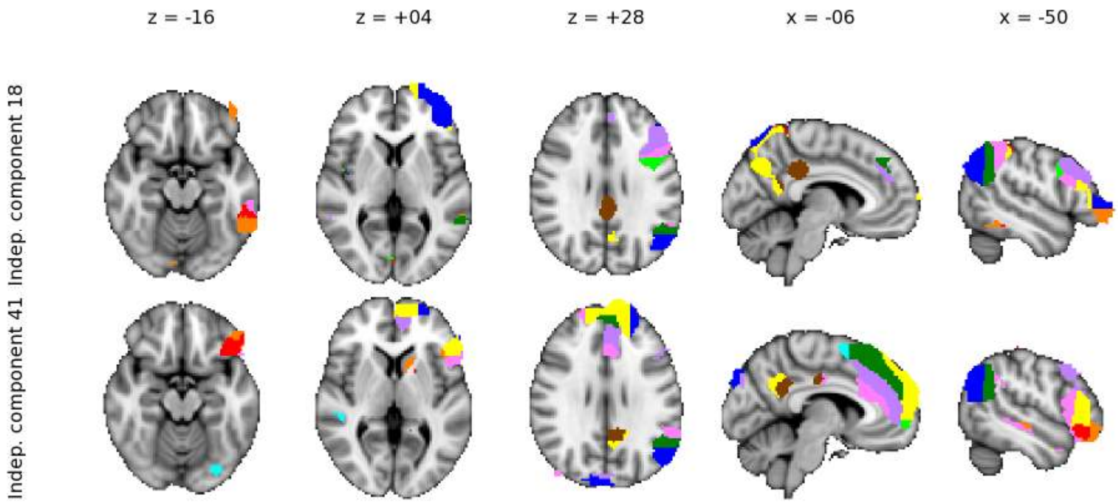

Figure 3 - Independent components 18 and 41 selected from the model-free analysis with MELODIC in the axial (z = -16, +04, and +28) and sagittal (x = -06, and -50) planes. Component 18 explains 1.44% of the total variance, and component 41 explains 0.74%. The active voxels are pictured in different colours, each colour corresponding to a different brain structure (see key in Figure 1). Radiological convention. MNI152 coordinates.

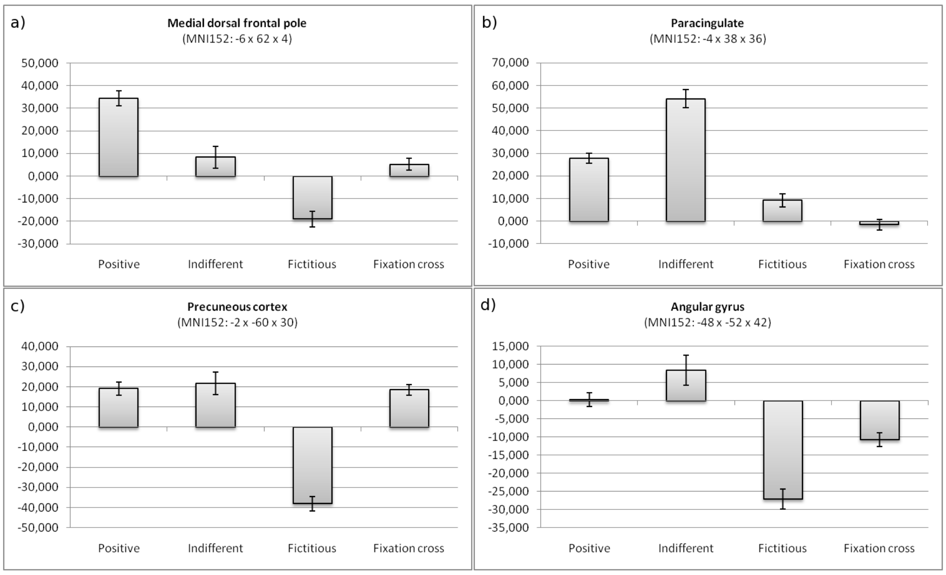

Figure 4 - Parameter estimates for positive, indifferent, and fictitious stimuli, and also for the fixation cross in four foci: the medial dorsal frontal pole, the paracingulate gyrus, the precuneous cortex, and the angular gyrus. The error bars refer to the confidence intervals at 95%. MNI152 coordinates

Supplementary materials

1 Choosing logos for stimuli

To choose the logos for the positive and indifferent categories, subjects previously completed an electronic survey, which took place in a time window ranging from a minimum of 4 hours and a maximum of 3 days. Along the survey, participants saw 200 brands' logos, which they had to rate in the *pleasure* and *arousal* dimensions of the PAD - pleasure, arousal, dominance scale (Mehrabian, 1995; Mehrabian & de Wetter, 1987; Russell & Mehrabian, 1977), by using the SAM - self assessment manikin (Bradley & Lang, 2007; Morris, 1995). As with static pictures (brands' logos) the third dimension, *dominance*, is highly correlated with *pleasure*, we did not include *dominance* in brands' assessments (Bradley & Lang, 2007). After this task, the responses were screened and categorized according to the following criteria: positive brands were those rated with more or equal to 7 in the *pleasure* dimension and more or equal to 5 in the *arousal* dimension; and indifferent brands were those rated with more or equal to 4 and less or equal to 6 in the *pleasure* dimension and less or equal to 5 in the *arousal* dimension. For each brand, the rate of *pleasure* was added to the double of the rate of *arousal*, and, in each group, the brands were ordered according to this index: in the positive brands group the order was decreasing and in the indifferent brands group the order was increasing. The first thirty five brands' logos of each group were selected for the fMRI session. Thus, positive and the indifferent brands stimulus were tailored to each participant.

2 Paradigm sequencing and answers recording

The paradigm sequences were programmed with SuperLab 4.0 software (version 4.0.6b; Cedrus Corporation, USA; http://www.superlab.com). The images were projected to a translucent screen installed in the scanner room, and the participants saw the screen with the aid of a mirror attached to the scanner antenna.

Subjects made their options by the means of a button box (model Lumina LU400-PAIR; Cedrus Corporation, USA; http://www.cedrus.com). Responses were recorded together with the reaction time. Before the scanning session all the participants had the opportunity to train the responses inside the scanner, and the scanning session began only after a perfect accommodation to the response pads.

3 Human Participants

The participants were eighteen, seven healthy male and eleven healthy female volunteers, right handed, with neither history of neurological nor psychiatric disturbances (mean age 28.2 years, ranging 19 – 41 years). Seven participants came from outside of the campus. Informed consent was obtained in all cases. A safety form for magnetic resonance imaging (MRI) was filled by every participant and discussed with a Neuroradiologist and a Radiographer. After each session the participants were debriefed. This research project adhered to the Declaration of Helsinki and was approved by the Ethics Committee.

4 Data Acquisition

Functional images with axial orientation were obtained using a T2*-weighted EPI sequence in a Siemens® Magnetom Trio high field (3 Tesla) MRI scanner (Siemens AG, Germany) (TR = 3000 ms, TE = 30 ms, 64 x 64 matrix, FOV = 192 mm, 3.0 mm axial slices). The order of acquisition of the slices was interleaved, and they covered the whole brain. The study consisted in one session where 407 volumes were acquired. The first four volumes were discarded to ensure pulses stabilization, and the last three were maintained to ensure capturing all the hemodynamic response.

A whole brain anatomical structural scan was acquired also for each volunteer, using a T1-weighted MPRAGE protocol (256 x 256 matrix, FOV = 256 mm, 3.0 mm axial slices), for co-registration purposes. Gradient field mapping was additionally acquired for image quality control.

5 Image pre-processing

In the FEAT analysis, the following pre-statistics processing was applied; motion correction using MCFLIRT (Jenkinson, Bannister, Brady, & Smith, 2002); slice-timing correction using Fourier-space time-series phase-shifting; non-brain removal using BET (S. M. Smith, 2002); spatial smoothing using a Gaussian kernel of FWHM 5mm; grand-mean intensity normalization of the entire 4D dataset by a single multiplicative factor; highpass temporal filtering (Gaussian-weighted least-squares straight line fitting, with sigma=30.0s). Time-series statistical analysis was performed using FILM with local autocorrelation correction (Woolrich, Ripley, Brady, & Smith, 2001). Registration to high-resolution structural and/or standard space images was done using FLIRT (Jenkinson, et al., 2002; Jenkinson & Smith, 2001).

Supplementary Table 1 - Assessments during the scanning sessions separated according to the type of stimuli.

Stimuli	Recorded options					Total
	Positive	Indifferent	Negative	Unknown	No answer	
Positive	590	29	3	6	2	630
Indifferent	82	427	74	44	3	630
Fictitious	33	36	2	554	5	630
Total	705	492	79	604	10	1890

Supplementary Table 2 - Activated voxels (2 × 2 × 2 mm) for the conjunction of the contrasts between positive and indifferent brands versus fictitious logos (Conjunction), and for two independent components from the PICA analysis (IC18 and IC41).

Brain structure	Total	Conjunction		IC18		IC41	
	voxels	voxels	fraction	voxels	fraction	voxels	fraction
Frontal pole ventral medial	3981	428	10,8%	0	0,0%	157	3,9%
Frontal pole ventral left	2617	1143	43,7%	599	22,9%	271	10,4%
Frontal pole dorsal medial	5884	1993	33,9%	248	4,2%	2851	48,5%
Frontal pole dorsal left	4214	1083	25,7%	959	22,8%	798	18,9%
Frontal medial cortex	1539	155	10,1%	0	0,0%	9	0,6%
Paracingulate gyrus	4095	377	9,2%	129	3,2%	1431	34,9%
Frontal orbital cortex left	2105	95	4,5%	2	0,1%	521	24,8%
Frontal operculum cortex left	562	0	0,0%	0	0,0%	95	16,9%
IFG pars triangularis left	1147	0	0,0%	222	19,4%	743	64,8%
IFG pars opercularis left	1205	0	0,0%	231	19,2%	486	40,3%
Superior frontal gyrus	8861	856	9,7%	831	9,4%	2634	29,7%
Middle frontal gyrus left	4331	985	22,7%	2533	58,5%	1204	27,8%
Inferior temporal gyrus – anterior left	592	104	17,6%	0	0,0%	0	0,0%
Inferior temporal gyrus – posterior left	1699	266	15,7%	74	4,4%	0	0,0%
ITG – temporo-occipital left	981	10	1,0%	191	19,5%	0	0,0%
Medial temporal gyrus – posterior left	1616	468	29,0%	323	20,0%	148	9,2%
Medial temporal gyrus – posterior right	1653	276	16,7%	0	0,0%	2	0,1%
MTG – temporo-occipital left	1073	22	2,1%	283	26,4%	0	0,0%
Superior parietal lobule left	1737	17	1,0%	940	54,1%	0	0,0%
Supramarginal gyrus – posterior left	1414	379	26,8%	574	40,6%	354	25,0%
Angular gyrus left	1113	704	63,3%	689	61,9%	705	63,3%
Angular gyrus right	1675	500	29,9%	221	13,2%	10	0,6%
Precuneous cortex	7844	2411	30,7%	415	5,3%	342	4,4%
Lateral occipital cortex – superior left	5903	1456	24,7%	3530	59,8%	1040	17,6%
Lateral occipital cortex – superior right	5899	879	14,9%	1079	18,3%	660	11,2%
Cuneal cortex	1743	358	20,5%	2	0,1%	171	9,8%
Supracalcarine cortex	424	25	5,9%	2	0,5%	0	0,0%
Cingulate gyrus – anterior	4144	283	6,8%	0	0,0%	640	15,4%
Cingulate gyrus – posterior	4495	1750	38,9%	544	12,1%	368	8,2%
Caudate left	572	25	4,4%	0	0,0%	151	26,4%
Accumbens left	111	29	26,1%	0	0,0%	0	0,0%
Accumbens right	86	11	12,8%	0	0,0%	0	0,0%

Note. Conjunction voxels are the green ones bottom row in Figure 2.