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Covert brand recognition engages emotion-specific brain networks

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ABSTRACT

Consumer goods' brands have become a major driver of consumers' choice: they have got symbolic, relational and even social properties that add substantial cultural and affective value to goods and services. Therefore, measuring the role of brands in consumers' cognitive and affective processes would be very helpful to better understand economic decision making. This work aimed at finding the neural correlates of automatic, spontaneous emotional response to brands, showing how deeply integrated are consumption symbols within the cognitive and affective processes of individuals. Functional magnetic resonance imaging (fMRI) was measured during a visual oddball paradigm consisting in the presentation of scrambled pictures as frequent stimuli, colored squares as targets, and brands and emotional pictures (selected from the International Affective Picture System [IAPS]) as emotionally-salient distractors. Affective rating of brands was assessed individually after scanning by a validated questionnaire. Results showed that, similarly to IAPS pictures, brands activated a well-defined emotional network, including amygdala and dorsolateral prefrontal cortex, highly specific of affective valence. In conclusion, this work identified the neural correlates of brands within cognitive and affective processes of consumers.

Key words
Brand • IAPS picture • Emotion • Covert task • Visual oddball paradigm

Introduction

Emotions are a fundamental component of consumer behavior, and greatly influence purchase and consumption choices (Richins, 1997; Bagozzi et al., 1999; Laros and Steenkamp, 2005; Johnson and Stewart, 2005; Watson and Spence, 2007). According to this perspective, different custom's choices are biased by emotions: pre-purchase, purchase, consumption, disposal, and retrospective consideration of one's experiences. As well, even corporate strategies, such as advertising, packaging, retail environment organization, etc., are strongly influenced by the emotional dimension of purchasing.

Brands are widely used as means of socio-cultural interaction and individual self-fulfillment, so that can reasonably be considered as an integral part of the product. Given certain circumstances, consumers consider brands as their major object of interest, more than product attributes and even than the price. Moreover, consumers usually attach (symbolic) meaning to their preferred goods and services by the means of their brands (Elliott, 1997), and often develop personal relationships with these (Fournier, 1998), while consumption communities more and more frequently coalesce around brands (Muniz Jr. and O'Guinn, 2001). As such, brand identities can be associated to consumption experiences in

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positive (Carrol and Ahuvia, 2006; Albert et al., 2008) or negative (Kozinets and Handelman, 2004; Dalli et al., 2006) ways. For example, McClure et al. (2004) have recently demonstrated that brand knowledge clearly drives behavior and, in addition, significantly modulates response in decision-making brain regions.

Quantification of the affective responses towards brands is of great interest for marketing researchers, and could be very helpful to further understand consumer behavior. Indeed, the administration of verbally-mediated questionnaires and interviews represents the most widely used indirect methodology to investigate consumers' affect towards brands. However, accuracy and reliability of results severely depends on the compliance between consumer and interviewer, on the actual awareness of consumers about their own thoughts and feelings, and on their ability to verbally express them. For these reasons, behavioral questionnaires are not suitable to correctly isolate the emotional component of the complex interplay of affective, cognitive, and social aspects that characterizes consumer-brand relationship.

In vivo brain functional methodologies, such as functional magnetic resonance imaging (fMRI), are instead promising for investigating the neural correlates of economic behavior, and in particular of the emotional component triggered by brand recognition and recall (Chamberlain and Broderick, 2007; Klucharev et al., 2008; Schaefer et al., 2011; Plassman et al., 2012). Previous functional studies on the neural substrates of consumer-brand relationship suggested that anterior cingulated, prefrontal and orbito-frontal cortices, amygdala and hippocampus, ventral striatum – as part of the dopaminergic reward system –, and insula may have a significant role in modulating consumers' behaviour (Northoff et al., 2000; Hariri et al., 2002, 2006; Anders et al., 2004; Dolcos et al., 2004). These regions are deeply involved in several aspects of brands processing such as brand preference (i.e. the choice of one's favorite brand among different ones), brand association (i.e. the connection between brands and social status), brand revocation (i.e. familiarity and brand "strength"), brand loyalty, and brand emotional valence (see Plassmann et al., 2012, for a recent review). Specifically, Esch et al. (2012) have showed that the activity of insular cortices, generally implicated in the encoding of negative emotions and feelings like disgust and pain, was associated with the emotional salience of brands. Moreover, recent studies have suggested that the dorsolateral and ventromedial prefrontal cortices play a key role in brand evaluation, because their activity correlates with behavioral measures of consumers' choices (Hare et al., 2008; Chib et al., 2009; Plassmann et al., 2010). Interestingly, the emotional response can also drive the subsequent decision-making and it has been found associated with a greater preference consistency and stability in consumers' behaviour (Lee et al., 2009).

Generally, previous studies have applied explicit experimental paradigms, e.g. imagery task (Schefer et al., 2006; Schaefer and Rotte, 2007a,b), button press responses (Yoon et al., 2006), overt emotional rating (Erk et al., 2002), or buying decisions (Deppe et al., 2005), that could have biased both behavioural and functional results (Hariri et al., 2000, 2003; Keightley et al., 2003; Taylor et al., 2003). Moreover, most of these studies presented a limited number of product categories, e.g. beverages (Deppe et al., 2005), or cars (Erk et al., 2002; Schaefer et al., 2006; Schaefer and Rotte, 2007a,b), thus limiting any generalization to other item categories. Actually, from a methodological/procedural viewpoint, grouping of subjects and/or brands into homogeneous, wide preference/affective categories (Erk et al., 2002; Deppe et al., 2005; Schaefer and Rotte, 2007a,b) might have overlooked the influence of unpredictable social, cultural, experiential, and temperamental components on individual affective processing of brands, with some remarkable exceptions (Schaefer et al., 2011) that have explored the consumers' personality profile. And since the pattern of brain response markedly depends on stimulus characteristics (Blood and Zatorre, 2001; Anderson et al., 2003; Baumgartner et al., 2006), the presentation of a single category prevented from disentangling the common or the stimulus-specific neuronal patterns of emotional processing (for reviews see Davidson and Irwin, 1999; Phan et al., 2002; Murphy et al., 2003).

Here, we aimed at assessing the neural correlates of the affective component of consumers-brand relationship, thus demonstrating how simple perception of consumption symbols, such as brands, may affect brain regions modulating emotional response. fMRI was applied to measure the neural response to visually presented brand logos and complex emotional pictures selected from the International Affective Picture System ([IAPS], Lang et al., 2008) during a visual oddball paradigm that allowed both to mask aims to participants, and to estimate brain response to single emotionally-salient stimuli. Individual rating of brands was collected immediately after scanning. As previously demonstrated for IAPS pictures (Hariri et al., 2002; Britton et al., 2006; Viinikainen et al., 2010; Aldhafeeri et al., 2012), we expected that implicit presentation of brands activate emotional neuronal networks. Furthermore, emotional brain response to brands and IAPS pictures was supposed to include common and stimulus-specific pathways that could be disentangled by direct comparison across stimulus categories. In addition, the brain activation pattern was assumed to be so specific for emotional valence as to be significantly able to predict the affective valence of stimuli (Haxby et al., 2001).

Materials and methods

Subjects

Fifteen healthy right-handed Italian volunteers (seven females, mean age ± SD = 25 ± 3 years) participated in the experiment. Clinical examinations and laboratory tests were administered to rule out history or presence of any relevant medical, neurological or psychiatric disorder, and use of substance that could affect brain function or metabolism. All subjects had been medication-free for at least 4 weeks prior to the study, including over-the-counter medications. Written informed consent to participation was obtained from all volunteers after explanation of the experimental procedure and risks involved. The whole study was approved by the local Ethical Committee.

Stimuli

Stimuli consisted of four types of pictures: i) 151 colored scrambled pictures; ii) squares of 12 different colors; iii) 63 brand logos; iv) 320 pictures of the International Affective Picture System (IAPS). The IAPS is a well-established database of 944 emotional pictures of a wide range of semantic categories rated by a norm population of men and women separately (Lang et al., 2008). Each IAPS picture is coded by three dimensions, i.e. *valence* (ranging from negative over neutral to positive), *arousal*, and *dominance*. A subset of IAPS pictures was selected for presentation according to the valence dimension. Specifically, 80 pictures for each gender group with positive valence (norm ratings: 5.00-7.30 for men and 5.15-7.00 for women) and 80 with negative valence (norm ratings: 3.36-4.99 for men and 3.59-4.85 for women). IAPS pictures with higher (> 7.30) and lower valence scores (< 1.98) were discarded since their strong affective content (mutilations, erotic images, etc.) could have had unwanted effects on the emotional state of participants, thus preventing a valid comparison between brain responses to brands and IAPS pictures. For the same reason, IAPS pictures with extreme values of arousal were not presented. Valence and arousal values of IAPS pictures were not significantly correlated. The dominance dimension was irrelevant in this context.

Brand logos were selected from 13 different international product and service categories (clothing, sportswear, cars, transport, beverages, large retailers, computers, mobile phones, media, food, gas, telephone companies, cigarettes), that are well-known in Italy, and range from luxury to more ordinary products and services (Supplementary material, Supplement 1).

Experimental paradigm

A visual oddball paradigm was applied (Fig. 1). The task did not imply any kind of reward, and participants were unaware of the actual aims of the study. Stimuli were visually presented every 2 s, with 1.5 s fixed duration and 0.5 s inter-stimulus interval. Stimulation was controlled using Presentation® (Version 9.80, http://www.neurobs.com). For each subject, data acquisition was partitioned into 7 runs, each lasting 6 min and 30 s and containing 176 stimuli (151 *standards*, i.e. scrambled pictures; 19 *distractors*, i.e. 5 IAPS pictures with positive valence, 5 with negative valence, and 9 trademark logos; 6 *targets*, i.e. colored squares). For each run and subject, the color of the target was randomly chosen among 12 available colors. Therefore, each subject was presented all brands and a randomly selected subset of 35 positive and 35 negative IAPS pictures out of 160 available for each gender group. Each time series began and ended with 10-s rest and included two 176-s blocks of stimulation, separated by 18-s rest. A uniform gray

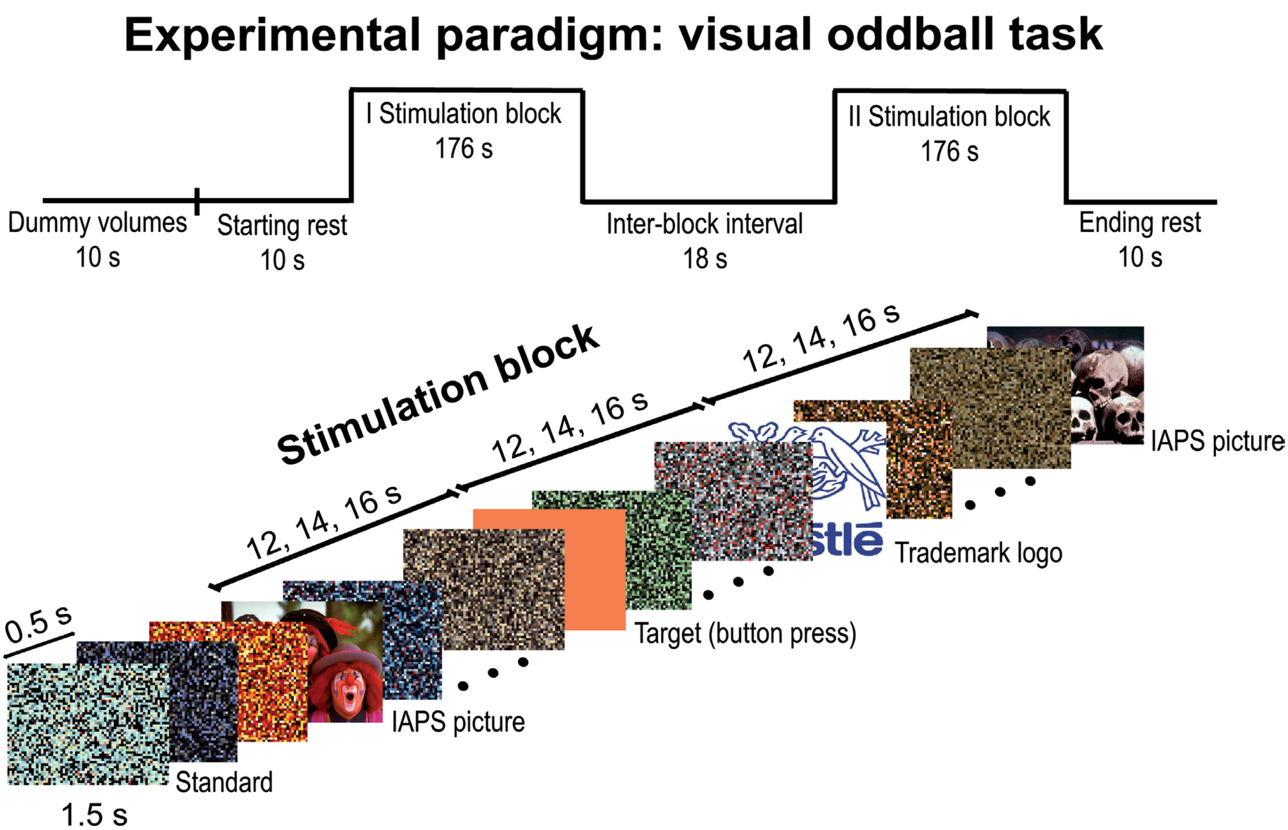

Fig. 1. - Experimental paradigm: visual oddball task with scrambled pictures as *standards*, IAPS (International Affective Picture System) pictures and brands as *distractors*, and colored squares as *targets*. Subjects were instructed to focus on visual stimuli and to press a button on detection of targets.

screen was displayed during resting periods. The order of stimuli was differently randomized for each subject and the interval between two consecutive non-scrambled pictures (either distractors or targets) was randomly chosen among 12, 14, and 16 s. Subjects were instructed to focus their attention on the visual stimuli, and to press a response button with their right thumb on detection of a target.

fMRI recording

Multi-slice echo-planar images (EPIs) were acquired in the axial plane on a 1.5 Tesla Signa MRI scanner (GE Medical Systems, Milwaukee, USA) with TE = 40 ms, TR = 2.5 s, flip angle 90°, FOV = 240 mm with 128 x 128 acquisition matrix (1.875 mm x 1.875 mm in-plane resolution) and 21 contiguous 5-mm slices. Each functional run consisted of 160 brain volumes and the first four (dummy volumes) were discarded from analysis. Stimuli were projected onto a screen located near the bottom of the bore and viewed from a mirror mounted on the head coil. A high resolution T_1-weighted spoiled grass structural scan (SPGR) was acquired at the beginning of the recording session (TE = 3.58 ms, TR = 19.58 ms, flip angle 10°, FOV = 240 mm with 0.469 x 0.469 mm in-plane resolution, 512 x 512 acquisition matrix, and 1 mm axial slice thickness).

Debriefing questionnaire

Immediately after the fMRI session, participants were asked to fill out a paper form questionnaire (Supplementary material, Supplement 2). In addition, attitude towards each brand was measured on a three-item scale (five-point semantic differential type): Good/Bad, Desirable/Undesirable, Pleasant/Unpleasant (Bruner and Hensel, 1992, p. 82; Bruner et al., 1998, p. 81). The order of trademark logos was randomized for avoiding sequence effects. This three-item scale prevented biases related to single-item measurements, while limiting the duration of the questionnaire. For each logo, a *composite index* of affective valence was computed by summing up the three items, thus obtaining an integer value between 3 (positive score) and 15 (negative score). Results are summarized in Supplementary material (Supplement 3). Furthermore, similarly to the characterization of the IAPS pictures, the arousal dimension of each logo was measured on a five-point semantic differential type Excited/Calm scale. Finally, in order to control for unknown brands, familiarity was also assessed for each logo using a five-point semantic differential type Known/Unknown scale. This part of the questionnaire was administered in a computerized form using Presentation® (Version 9.80, http://www.neurobs.com).

fMRI Analysis

Structural and functional images were analyzed with the AFNI software (http://afni.nimh.nih.gov/afni, Cox, 1996). Before statistical analysis, single-subject fMRI data were pre-processed by slice timing and rigid head movements correction, spatial smoothing with isotropic Gaussian filter (σ = 3 mm), and global mean intensity normalization to calculate the percent signal change.

Then, functional images time series at each voxel was fitted to a multiple linear regression model by least squares method. The impulse hemodynamic response function (HRF) was modeled as the default Cox special waveform (peak value = 1) (http://afni.nimh.nih.gov/afni/doc/faq/17) convolved with a boxcar function of duration 2 s. Brain response to scrambled pictures was modeled by a single regressor obtained by summing the impulse HRFs to all standards. Brain response to each distractor and target was modeled by a separate impulse HRF, thus resulting in the estimation of 175 single-event regression coefficients (β). Three rotation and 3 translation head motion parameters concatenated across runs and a different quadratic drifting for each run were added as confounds.

After spatial warping into the Talairach and Tournoux atlas (1988) and resampling to 1 mm^3 voxels, random effect group analysis (second level analysis) was performed to account for inter-individual variance, using the appropriate individual statistical contrast images.

i) Individual overall *F*-statistics were transformed to *Z*-score, averaged across subjects, and scaled by the square root of the sample size for computing an overall group *Z*-map.
ii) A one-sample *t*-test statistic across subjects was applied to identify brain regions significantly and distinctively activated by each stimulus category as compared to rest (voxel-wise threshold $P < 0.001$ and minimum cluster volume of 87 μl, corresponding to a small volume corrected (SVC) $P < 0.05$ estimated from Monte Carlo simulations via AlphaSim in AFNI on the group *Z*-map at *Z* score > 15).
iii) Emotionally-salient stimuli, i.e. IAPS pictures and brands, were classified as "positive" and "negative" according to standardized valence for IAPS pictures (Lang et al., 2008), and to individual composite index of affective valence for brands. Individual contrast images were estimated by averaging single-event regression coefficients (beta-weights) by stimulus category and emotion polarity. Mixed-effect model analysis of variance (one-way within-subjects ANOVA) – with 15 subjects as random factor and stimulus type as fixed factor (4 levels: positive and negative IAPS pictures and brands) – was applied for comparing brain responses to IAPS pictures and brands and to positive and negative stimuli. Significant differences in brain activation between levels were computed by post-hoc *t*-tests with SVC $P < 0.05$ (voxel-level $P < 0.05$, minimum cluster size of 369 μl).
iv) Voxel-based linear correlation (ρ) between single-event regression coefficients (beta-weights) and corresponding affective valence of stimuli was computed separately for IAPS pictures and brands, to spatially map the neural activity linearly modulated by affective valence (SVC $P < 0.05$).
v) Spatial correlation analysis was applied to evaluate whether the pattern of neural response to emotionally-salient stimuli was highly specific of emotion polarity, i.e. positive and negative affective valence. Individual contrast maps identifying voxels that differentially activated (uncorrected $P < 0.01$) in response to positive or negative stimuli for each category (brand logos or IAPS pictures) were used to restrict the spatial correlation pattern analysis. Similarity was measured as spatial correlation between patterns of response to positive and negative stimuli on odd and even runs separately, after voxel-by-voxel subtraction of the mean response across these categories (Haxby et al., 2001). This procedure was applied to IAPS pictures and brands both separately and merged

together. In addition, similarity of the pattern of emotional response between positive/negative IAPS pictures and positive/negative brands considering all runs together was also evaluated.

Results

As intended by the experimental paradigm, no participant realized the true aim of the study up to the time of debriefing questionnaire: this result further confirms that recorded brain activity represented the authentic spontaneous emotional response to brands.

Attitude towards brands

The reliability of the three-item scale applied for measuring affective attitude towards brands was very high (Cronbach's Alpha = 0.914). The composite index was characterized by a nearly-Gaussian distribution, with mean ± SD = 8.46 ± 0.11 and mode = 9 (Supplementary material, Supplement 3, Fig. 1S). Considering all subjects together, it was possible to identify a subset of favorite (composite index < 6.5) and a subset of less preferred brands (composite index > 10.5). Furthermore, some brands showed a moderate profile, with most of ratings falling in the middle of the scale, while other brands presented ratings at the both extremes. As expected, different subjects often rated differently the same brand and showed different bias towards positive, neutral, or negative evaluations: the mean value of the composite index ranged from 6.7 for the more positive-oriented subject to 10.3 for the more negative-oriented one. Then, brands were classified as positive and negative on an individual basis: the extreme quartiles of the individual distribution of the composite index were extracted for identifying the most liked and the most disliked brands for each subject, while the remaining of the distribution indicated the neutral brands (Supplementary material, Supplement 3, Fig. 2S).

Arousal rating of brands showed an asymmetric distribution towards calm, with 78.4% of ratings falling between 3-5. Arousal scoring were not significantly correlated with the composite index of affective valence of brands. Familiarity score of 94.4% of all trademark logos fell between 1-3, with 1 meaning well-known. Therefore, presented brands were highly familiar to all participants.

Brain functional findings

Stimulus-specific brain responses

Brain activation related to scrambled pictures was mostly located in bilateral visual cortex (BA 17-18), extending to the ventral lingual and fusiform gyri, left anterior portion of the superior frontal cortex, inferior frontal gyrus and dorsolateral prefrontal (PFC) cortex (Fig. 2, Supplementary material, Supplement 4, Table IS). Brain response to targets was characterized by significant activation of the bilateral primary visual cortex and middle occipito-temporal cortex (BA 19/39), inferior parietal lobule, right insula and dorsolateral PFC. IAPS pictures engaged bilateral visual cortex, and middle temporal gyrus (BA 37/39), left dorsolateral PFC, ventral inferior and superior frontal gyrus. Cortical activations related to brands were observed in the bilateral primary visual cortex and in the left fusiform gyrus, middle temporal gyrus, dorsolateral PFC and superior frontal gyrus. Bilateral engagement of subcortical structures, specifically parahippocampus and amygdala, was observed in correspondence to IAPS pictures and brands only. Some cortical regions involved in the default mode system (Raichle and Snyder, 2007) showed significantly reduced activation as compared to rest condition, e.g. bilateral precuneus, parietal cortex, and posterior cingulate (Fig. 2, Supplementary material, Supplement 4, Table IS).

Contrasted with brands, IAPS pictures showed significantly greater activation in primary visual, including bilateral lingual and right fusiform gyri, and middle occipito-temporal cortex (BA 37/39). In addition, higher activation was found in the right inferior parietal lobule (BA 40), and left middle frontal gyrus (BA 9/10). On the contrary, brain activation was significantly higher for brands as compared to IAPS pictures in the bilateral angular gyrus and left middle temporal gyrus (Table I).

Valence-specific brain responses

Analysis of variance. Greater activation for positive than negative IAPS pictures was located in the left superior temporal pole, bilateral superior frontal cortex, medial frontal gyrus, and paracentral lobule. The opposite occurred in the right inferior frontal gyrus (BA 6/44/45) and left dorsolateral PFC (BA 9/46) and precuneus. Positive brands were related to greater engagement of the right dorsolateral PFC

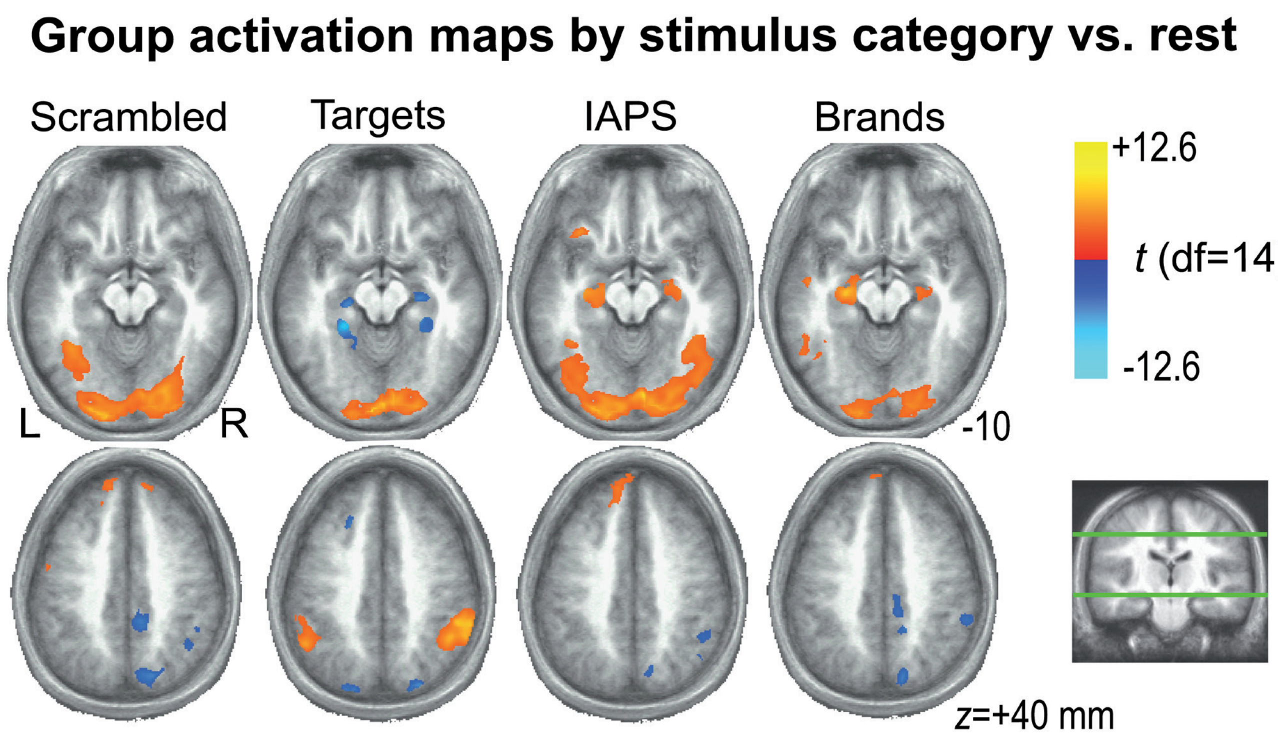

Fig. 2. - Brain response to each stimulus category vs. rest. One-sample *t*-test statistic across subjects comparing each stimulus category vs. rest (SVC $P < 0.05$). L = left; R = right; df = degrees of freedom.

(BA 44/45/46) as compared to negative brands, that in turn activated to a greater extent the left middle temporal gyrus, the medial portions of the anterior cingulate and superior frontal gyrus, and the bilateral middle frontal gyrus (Fig. 3 and Table I).

Linear regression. The more positive the affective scoring of either brands or IAPS pictures, the greater the brain activation in bilateral fusiform gyrus, left temporal polar cortex, right dorsolateral PFC (BA 9/46), right precentral gyrus, right superior parietal cortex (BA 40) and medial paracentral lobule. Significant increase of hemodynamic response with *positive* ratings of IAPS pictures was observed in the right superior and medial frontal cortex (BA 9/10) and with *negative* ratings in the right inferior frontal gyrus (BA 44/45) and left dorsolateral PFC (BA 9/44). Engagement of left amygdala, superior parietal lobule, and dorsolateral PFC (BA 9/46), of right dorsolateral PFC (BA 44/45) and middle frontal cortex (BA 10), of medial frontal gyrus (BA 24), of bilateral caudate nuclei, middle temporal-occipital (BA 19/39), and superior temporal gyri significantly increased with *positive* ratings of brands, while only the response of medial precuneus significantly increased with *negative* ratings of brands (Fig. 3 and Table I).

Spatial correlation analysis. In all subjects, the emotional valence of stimuli could be exactly inferred from the spatial correlation between the patterns of response evoked by positive and negative stimuli on even and odd runs for either IAPS pictures or brands (Fig. 4). In fact, stronger within-emotional-valence correlations in each stimulus category, as compared to between-emotional-valence correlations, indicate the existence of emotional valence-related patterns of response for IAPS pictures and brands either considered separately or merged together. Thus, the patterns of response within those individual voxels that differentially activated in response to positive or negative stimuli for each category correctly identified the category being viewed in all pairwise comparisons.

On the contrary, when comparing IAPS pictures and brands (between categories contrasts), spatial correlations within emotional valence (positive IAPS pictures and brands, or negative IAPS pictures and brands) was higher than spatial correlation between

Table I. - (a) One-way within-subjects ANOVA (15 subjects as random factor and stimulus type as fixed factor with 4 levels: positive and negative IAPS pictures and brands; SVC $P < 0.05$). Local maxima coordinates (x, y, z) in the Talairach and Tournoux atlas (1988) and corresponding *t* value of post-hoc *t*-tests. (b) Linear correlation analysis between single-event regression coefficients and corresponding affective valence of stimuli (SVC $P < 0.05$). Local maxima coordinates (x, y, z) in the Talairach and Tournoux atlas (1988) and corresponding correlation (ρ) value computed on normalized valence between 0-1. H = hemisphere; L = left; R = right; BA = Brodmann's area.

Brain areas		BA	H	(a) One-way within-subjects ANOVA												(b) Linear correlation							
				IAPS-Brands				Pos-Neg IAPS				Pos-Neg Brands				IAPS				Brands			
				t	x	y	z	t	x	y	z	t	x	y	z	r	x	y	z	r	x	y	z
Subcortical	Parahipp/Amygdala		L																	0.27	-20	-6	-13
	Caudate		L																	0.19	-5	9	7
			R																	0.20	10	13	12
Striate/ Extrastriate	Lingual gyrus	17/18	L	3.8	-15	-95	0																
			R	5.4	30	-78	-4																
	Fusiform	37	L													0.26	-40	-46	-15	0.67	-39	-73	-14
			R	5.9	39	-40	-15									0.31	40	-39	-17	0.59	40	-59	-16
	Middle Temp-Occip	19/39	L																	0.39	-26	-85	28
			R																	0.40	28	-83	25
		37/39	L	5.5	-42	-67	11																
			R	7.1	53	-62	4																
	Angular	39	L	-3.4	-43	-66	37																
			R	-3.5	46	-57	25																
Temporal	Middle	21	L	-4	-63	-34	2																
				-3.6	-54	-43	-6					-3.1	-56	-23	-5								
	Superior	21/22	L																	0.36	-56	-53	21
			R																	0.37	59	-40	22
	Temporal Polar	21/38	L					4.2	-46	3	-14					0.45	-46	2	-14	0.37	-54	-6	-13
Parietal	Precuneus	7	L/R					-3.6	6	-65	31									-,30	-1	-64	29
	Inferior Parietal	40	R	3.1	56	-38	35																
	Superior Parietal	40	L																	0.36	-33	-53	59
			R													0.26	32	-32	56	0.36	30	-51	63
	Paracentral Lobule	7	L/R					3	-2	-30	57					0.25	0	-32	55	0.34	2	-30	54
Frontal	Anterior Cingulate	24/32	L/R									-4.6	15	40	3								
	Inferior Frontal	44/45	L																				
			R					-3	48	23	10					-0.50	58	13	14				
		6/44	R					-2.9	50	0	16												
	Dorolateral PFC	9/44	L					-4.9	-51	9	34					-0.27	-50	10	33				
		44/45/46	R									3.2	53	29	12					0.28	53	28	15
		9/46	L																	0.23	-35	39	26
			R													0.45	51	34	24	0.40	49	38	23
	Superior Frontal	6/8/9	L																				
		6	R													0.27	24	21	55				
			L					3.6	-25	43	37												
			R					5.7	17	45	41												
	Middle Frontal	8	L									-3.3	27	26	39								
			R									-3.1	-33	24	45								
		10	L	3	-16	53	20																
			R																	0.47	30	47	8
	Precentral	6	R													0.27	14	-12	68	0.51	31	-14	66
	Medial Frontal	9/10	L/R					4.5	10	52	17					0.72	2	62	7				
		8	L/R									-3.1	8	38	39								
		24	L/R																	0.25	2	9	35

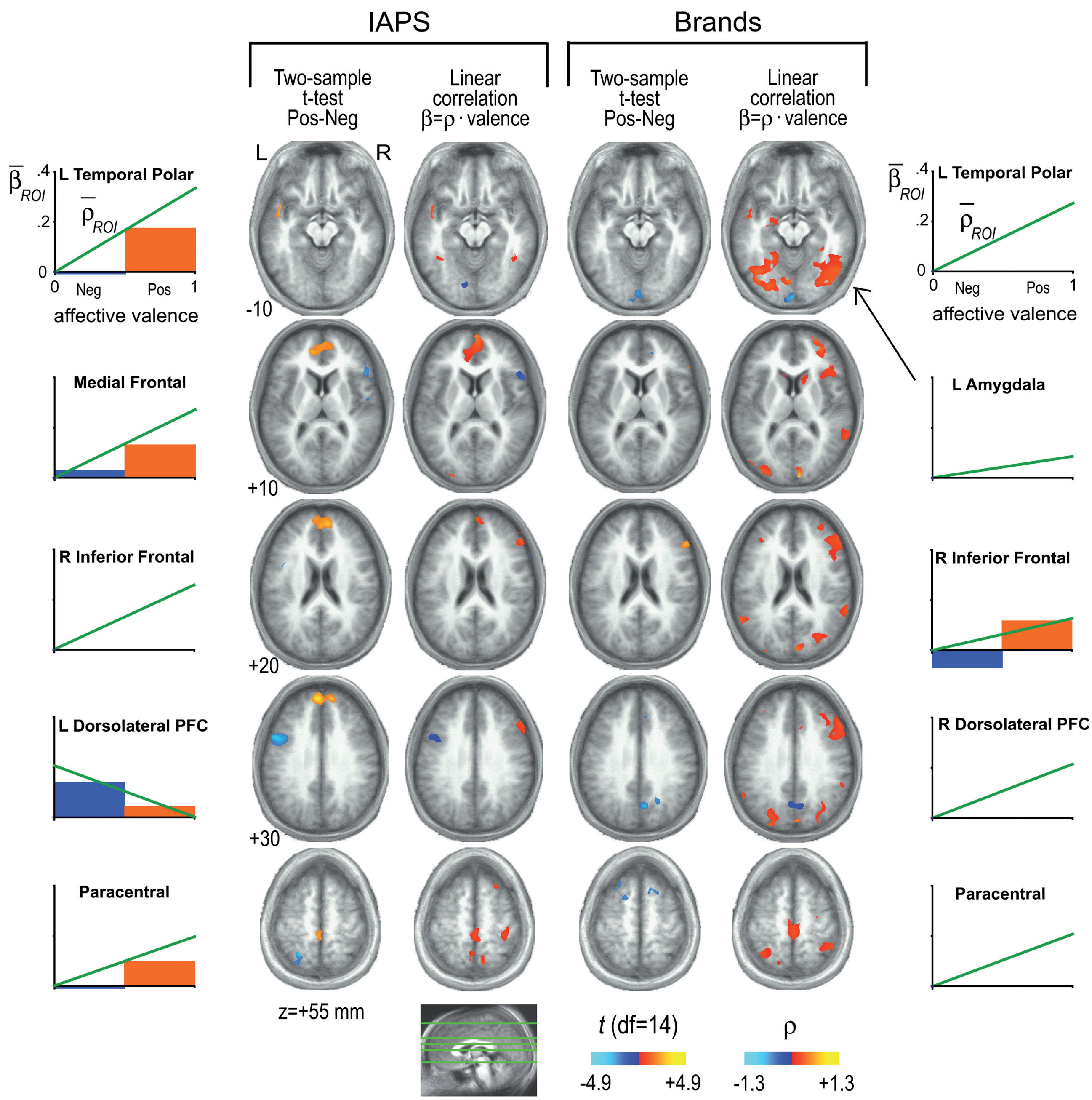

Fig. 3. - Two-sample *t*-test analysis between positive and negative IAPS pictures and brands and linear correlation between HRF regression coefficients and affective valence of single IAPS pictures and brands (SVC $P < 0.05$). Lateral graphs show the average regression coefficients ($\bar{\beta}_{ROI}$) associated to negative (blue bar) and positive stimuli (orange bar) and/or the average linear correlation lines ($\bar{\rho}_{ROI}$, green line) for some regions of interest (ROI), obtained by merging the statistically significant voxels surrounding local maxima. Affective valence score was normalized between 0 (negative) and 1 (positive). L = left; R = right; df = degrees of freedom.

emotional valence (positive IAPS pictures and negative brands, or negative IAPS pictures and positive brands) in only 53% of subjects. Therefore, it was not possible to confidently guess the valence category of brands from the pattern of response to positive and negative IAPS pictures.

Discussion

This work aimed at identifying the neural traces of emotional responses towards brands, which are consumption symbols undoubtedly related to physical products but, at the same time, conveying

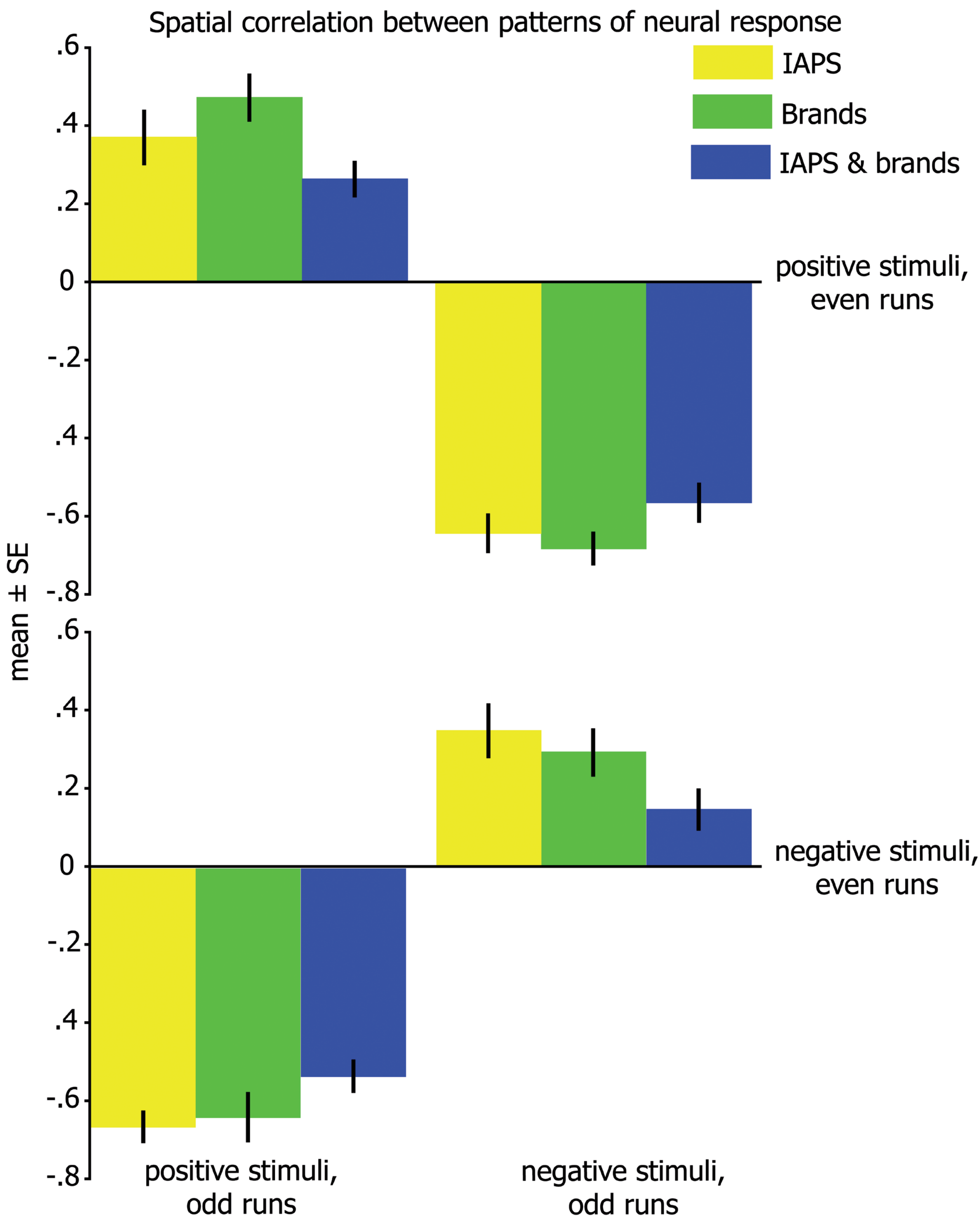

Fig. 4. - Correlation between patterns of neural response to positive and negative stimuli on even and odd runs. Spatial correlation analysis was restricted to those voxels with significantly different activation (uncorrected $P < 0.01$) by emotion polarity for each stimulus category.

strong social, cultural, and emotional messages. Brain activity was measured with fMRI during a visual oddball paradigm consisting in the presentation of scrambled pictures as frequent stimuli, colored squares as targets, and brands and IAPS pictures (Lang et al., 2008) as emotionally-salient distractors. Affective rating of brands was individually assessed through a validated questionnaire and used to determine how simple perception of such consumption symbols may affect brain regions modulating emotional response, as compared to the neural responses to standardized IAPS pictures. Accordingly, a pattern of brain activation, including dorsolateral PFC, ventro-temporal and superior parietal regions, was significantly modulated by stimulus valence, and either preferentially or commonly engaged by brands and generic affective pictures. Interestingly, the specificity of the neural responses for affective valence allowed a correct identification of the emotional category, either positive or negative, of IAPS pictures as well as of brands from brain activation maps.

These observations demonstrated that brain response to brands automatically involves an implicit affective component, highly differentiated according to emotion polarity and playing a primary role in the evaluation of consumer goods. Nonetheless, inference of emotion polarity from brain responses was successful only within-stimulus categories, while the neural activation maps of positive/negative IAPS pictures were not suitable to predict emotion polarity of brands, and viceversa. Indeed, the comparison between positive and negative stimuli showed rather different functional maps for IAPS pictures and brands, suggesting that emotional evaluation of these two stimulus categories relies on partially different mechanisms.

In detail, perceptual processing of IAPS pictures and trademark logos required the activation of a complex brain network where specific areas play a key role in peculiar aspects in the evaluation of emotional stimuli. Specifically, prefrontal cortex has been shown to play a central role in the representation of distinct emotion dimensions (Dolcos et al., 2004; Grimm et al., 2006; Wager et al., 2008). In particular, the results presented in this study are consistent with previous evidences of increased activity in the ventromedial prefrontal cortex and decreased recruitment of left dorsolateral prefrontal areas for positive as compared to negative IAPS pictures (Grimm et al., 2006).

Modulation of amygdala activity with affective valence or intensity of visual stimuli is currently debated, since involvement of this brain region has been reported in many different conditions, e.g. presentation of happy faces (Britton et al., 2006), unpleasant pictures (Takahashi et al., 2004), negative facial expressions (Hariri et al., 2002), positive and negative pictures and faces (Aharon et al., 2001; Keightley et al., 2003). In the present study, IAPS pictures did not activate the amygdala, likely because of the deliberate presentation of IAPS pictures with intermediate other than extreme values of affective valence. On the contrary, the engagement of the left amygdala was specifically elicited by brands and increased significantly with positive affective ratings, consistently with previous functional studies showing a specific linear correlation between left, but not right, amygdala response and parametric increase of rewarding conditions (Zalla et al., 2000). Therefore, it is possible to argue that the emotional, social, and cultural value of brand recognition are capable to activate deep reward circuits, even to a significantly greater extent than generic images. This observation further supports the hypothesis of strong emotional relationship between consumers' preferences and brands, and the importance of investigating this phenomenon with objective and quantitative methods.

Moreover, this study confirms previous demonstrations of the engagement of the reward system by socio-cultural objects, specifically brands. In fact, Erk et al. (2002) have shown that sportscars activate the striatum, orbitofrontal cortex, and dorsolateral prefrontal gyrus to a greater extent than small cars. In our study, activation was observed in the left amygdala, caudate nucleus, and inferior frontal cortex. These results indicate that activation of the reward circuitry is not restricted to stimuli with an intrinsic reward value, e.g. sexual (Aharon et al., 2001), financial (Pochon et al., 2002; Dreher et al., 2006; Liu et al., 2007) and food (Beaver et al., 2006) stimuli.

The specific patterns of neural responses appeared to be more robust during linear regression analysis as compared to ANOVA, especially for brands. The reason may lay in the quite arbitrary dichotomous categorization of brands into positive and negative categories. In fact, affective rating of brands well resembles a continuous line from negative to positive. Similar considerations hold also for IAPS pictures, since they have been deliberately selected around neutral values of affective valence, where the positive/negative boundary is smooth and slowly sloping.

Results obtained in this study on IAPS pictures are only partially comparable with previous literature (Hariri et al., 2002; Britton et al., 2006), because different ranges of valence and arousal have been employed. Usually, other studies have presented IAPS pictures with extreme values of valence and arousal, considering intermediate values as neutral (i.e. control condition). However, since the emotional impact of brands is expected to be rather limited, this work specifically used IAPS pictures with values of valence and arousal only slightly biased towards positive and negative affect, in order to make the implicit affective perception of these two stimulus categories (IAPS images and brands) as much comparable a possible. These issues will be possibly addressed in future studies, thus enabling the extraction of more general characteristics of emotional brain responses across stimulus categories.

The experimental paradigm successfully overcame the limitations of previous works, such as the use of explicit tasks and few product categories, and the application of slow block-design paradigms (Canli et al., 1998; Erk et al., 2002; Deppe et al., 2005; Britton et al., 2006; Schaefer et al., 2006; Yoon et al., 2006; Schaefer and Rotte, 2007a,b). This study first systematically investigated the spontaneous, automatic activation of emotional brain circuits during covert brand recognition, since the true experimental aim was carefully masked to participants by means of a visual oddball paradigm. Furthermore, the short stimulus duration did not leave the subject enough time for reasoning, as occurred in previous studies (Schaefer et al., 2006). Highly implicit emotional response is a crucial aspect for interpretation of results, since cognitive processes have been shown to severely modulate neural response of basic emotional circuits (Hariri et al., 2000; Keightley et al., 2003; Taylor et al., 2003). The variety of brands presented virtually covered all the most common product categories, thus preventing that results could be affected by arbitrary brands selection. Unlike block-design experiments, the present paradigm allowed to estimate the hemodynamic response for each stimulus separately: therefore, it was possible to fully exploit the variety of single-brand individual emotional rating and to perform correlation analysis between brain response and affective valence. The reason for frequent presentation of scrambled pictures consisted in steadying the activation of "perceptual" primary areas across stimulus categories, and in temporally spacing the stimuli of interest in order to avoid systematic overlapping of their hemodynamic responses without driving down subjects' attention. Finally, confounding factors like size, position, background and luminance were carefully controlled for all stimuli, thus preventing any bias that could be related to different visual and graphical properties of the two classes of stimuli.

Brand knowledge affects behavioral preference and significantly modulates hemodynamic brain activity during a primary reward like drinking (McClure et al., 2004). The present experimental protocol provided the common as well as the specific features of spontaneous affective brain response to brands and to generic emotionally-salient scenes, taken from the IAPS database. The random selection of a subset of IAPS pictures from a larger predefined group for presentation to each subject partly justified the use of standardized affective valence scores. Moreover, individual emotional ratings of brands effectively accounted for inter-individual variability of judgment, that was actually evident from post-scan questionnaire results. In fact, individual experience and socio-cultural influences are expected to markedly affect affective attitude towards brands to a greater extent than generic complex pictures with positive/negative common sense content.

In conclusion, this work first showed that even when subjects are engaged in a different perceptual task, implicit exposure to brands elicited distinct responses in emotional neuronal networks, that reflected highly selective positive and negative reactions. These findings might justify the leading role of emotions, as compared to rational thinking, often observed in consumers' choices on one hand and consequently in advertisement strategies on the other.

The results of this study confirm that measuring the affective responses towards brands with functional brain imaging may become very helpful for marketing research, because it may give a proper account of the role of emotions in cognitive processes underlying consumers' behavior. Unlike conventional verbally-mediated questionnaires and interviews, fMRI measurements accurately represent neuronal activation and are not influenced by the interaction between the interviewer and the interviewee.

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