Perception of commercial brands and the emotional and social value: A spatiotemporal EEG analysis

Pedro Casademont Braddell Schiappa de Azevedo[a]

[a]Department of Physics, Instituto Superior Técnico, Universidade Técnica de Lisboa, Portugal

October, 2010

In this experimental work, we sought to deepen the knowledge of neuromarketing, particularly in what regards the role of brands in personal, emotional and social levels. The objectives were to study the neural substrates of the perception of logos confronting with results already published, and to contribute to the validity of the electroencephalogram as a suitable technique for the study of neuromarketing.

Twenty participants observed and evaluated 80 commercial brand logos, while a continuous 66-channel EEG was recorded. In the analysis the brands were divided into groups of preference and were confronted.

The results obtained with different methods of analysis showed differences between the groups: the most preferred brands show an increased late positive potential (LPP), suggested to be due to activations in the precuneus and the posterior cingulate cortex (PCC) as observed in the 3D images obtained with the LORETA method. Only the familiar brands elicited activations in the frontal cortex during the first second after the logo presentation, while only the most preferred produced significant activations in the anterior rostral MFC (BA 10).

Due to the participation of these regions in the processes of mentalizing and self-knowledge, we conclude suggesting that particular brands are used as symbols that transmit messages about oneself and about others.

Keywords: neuromarketing, commercial brands, EEG, emotion, logos

Introduction

Neuromarketing or ‘consumer neuroscience’ as some prefer to call, is a new area of research that uses neuroscientific methods and findings to better understand the neurophysiological fundamentals of consumer behavior (Hubert, 2008). It opens the possibility to look into the ‘gray box’ – the brain – in order to understand more deeply the needs and desires of the human being (Camerer, 2008). In the last decades, the importance of emotions in the process of decision-making and behavior is being increasingly recognized by marketers, but humans have a hard time describing their feelings towards a product, a brand or an ad (Marci, 2008). Whereas traditional economic and marketing theories are based in observed preferences or in the self-report of consumers, neuromarketing allows a direct and objective measurement of what is happening instantaneously in the mind of the consumer when, for example, he or she is making a decision (Lee 2007). The applications of neuromarketing are the same of marketing, as to understand how advertisement works, or to measure the value of a brand or even to know what product packaging will be more effective. Nonetheless its advantages over traditional marketing research will allow us to extend, modify or even negate the existing theories (Hubert, 2010). Many studies in different areas have been conducted: on brand impact (e.g. McClure, 2004; Deppe, 2005; Schaefer, 2006); on advertising effectiveness (Astolfi, 2009; Ohme, 2009); on price perception (Knutson, 2007; Plassmann, 2008); on product design (Erk, 2002); etc.

In this study we focus on the perception of commercial brands. The importance of brands has been recognized, in the staggering growth and competition of markets, since they serve as a differentiation factor and thus creating competitive advantage over the numerous equivalent associated products (McClure, 2004). Brands are not only classified by their functional benefits, but also by their emotional and self-expressive ones (Aaker, 1996). It’s the conjunction of all these that builds the value of a brand and in turn, affects people’s economic decisions (Schaefer, 2006).

Brands contribute in the process of construction of identity (Elliott & Wattanasuwan, 1998) in which we are continuingly evaluating what we possess and by using brands symbols as signal messages that allow our peers to categorize us too (Dittmar & Pepper, 1994).

Some studies of neuromarketing have been conducted trying to evaluate the importance of brands: McClure et al. (2004) in a famous study that compared two sodas, Coke with Pepsi, verified how brands serve as culturally-based cues to the process of decision-making, given more importance than sensorial information, and activating regions like the ventromedial prefrontal cortex (VMPFC) and the dorsolateral prefrontal cortex (DLPFC). Another study of Schaefer et al. (2006) verified that when people imagined themselves driving cars of familiar brands, dorsal regions of the frontal cortex (area 8, 9) were activated in comparison to driving cars of non-familiar brands. Also, Santos et al. (2008) studied the perception of brands, using the fMRI, and concluded that only the preferred brands and not the brands classified as indifferent activated regions of the medial frontal cortex. These regions have been associated with the process of mentalizing, which is the ability to represent another person's psychological perspective (Amodio & Frith, 2006) and thus contributing to the process of construction of social groups.

Aditionally in this study we pretend to assess the emotional value perceived in a brand. The emotional processes have been undervalued in the past by economic theories that defined human as rational decision-makers trying to maximize utility in their choices (Camerer, 2005). Damasio and co-workers have helped to bring emotion back to scene. They observed how lesions in the medial frontal cortex didn´t affect the rationality of the patients, but profoundly disturbed the process of feeling emotions and using them as markers to guide our behavior (1998).

Being aware of the present state of art of neuromarketing and brands, in this study we proposed ourselves to perform an exploratory study, using a multi-modal analysis method to study the perception of brands, more specifically, in their emotional and social levels.

On one hand we wish to take advantage of the methods used in cognitive and affective neuroscience and apply them to the study of brands, namely using EEG. First, there have been studies using the Davidson's asymmetry model, which states that the left frontal brain is involved in processing positive emotions related to approach behaviors and the opposite for the right frontal cortex (Harmon-Jones, 2009). These results are obtained measuring the Alfa frequency band (8-13Hz) which has been inversely correlated with brain activation (*idem*). Another possibility is the use of the event-related potentials calculated from the averaged signal of the EEG synchronized with the presentation of a stimulus (Barthlow, 2009). For example, studies show an increased LPP component (late positive potential aproximately between 400 and 600 ms) for emotional images when compared to neutral images (Cuthbert, 2000; Pastor, 2008), and we pretend to verify if the same processes happen with brands.

On the other hand we have the objective of validating EEG, by achieving similar results to that of other studies that used fMRI. To do this we'll use a much lesser powerful tool in terms of spatial resolution, the LORETA, that provides an estimate solution to the inverse problem. This technique has the advantage that with it we can study the brain dynamics that starts in the presentation of the stimulus, since its temporal resolution it's much better.

In practice, to do this, we posed some *a priori* research questions to study the perception of commercial brands. All these questions were posed to search for differences in the various types of brands presented. The first was to study the asymmetries of the brain response, possibly finding a more pronounced left activation for the positive- rated brands; the second, to study the ERPs components verifying if what was observed in emotional images was also applied in the study of brands and finally to estimate the source of the electrical activity measured, and obtaining different neuronal sources according to brand preferences, specially in the frontal cortex.

Materials and methods

Subjects

Twenty-two healthy male volunteers (mean age 23.1, SD 1.7), took part in the study and gave their written informed consent. All subjects were consistently right-handed with normal or corrected-to-normal vision. None of the subjects reported any neurological or psychiatric disease. .After completion of EEG data analysis, two subjects were excluded from group analysis due to excessive artifacts.

Experimental task

Participants were shown randomly 80 different brand logos, intercalated by non-emotional words that served as the baseline (Figure 1). During this, participants had to make explicit cognitive assessments of commercial brands, as instructed using a special keyboard made, specially, for this experience. The possible ratings were "unknown", "negative", "indifferent", or "positive".

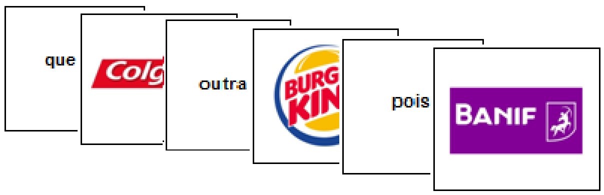

Figure 1 – Example of a possible part of a sequence of presentation of the stimuli. These slides were presented over the black background of the monitor.

The 80 brands were taken from the internet, and specifically, one fourth was taken from foreigner markets to serve as forced unknown brands. In order to have aproximately the same weight on each of the three groups left, pre-tests were made on two other subjects.

All slides were presented using Eprime 2.0 software (www.pstnet.com), during 6-s on a computer monitor. Stimulus presentation and responses were synchronized, by sending a trigger to the amplifier.

After the experience, subjects completed a Likert 5-point questionnaire of the same logos. Note that the responses in the experience that didn't match those given on the Likert test were excluded from the following analysis.

Data acquisition and analysis:

EEG data were collected from 66 channels, using the international 10-10 system. 60 electrodes measured the electrical activity in the scalp and 4 bipolar near the eyes to measure the eye blinks and movements and 2 in each earlobe; all referred to an average reference. A sampling rate of 500 Hz was used with an analog pass band between 0.01 and 100 Hz and a notch filter at 50 Hz. (QuickAmp-72, Brain Products, Germany and custom cap, Electro Cap International, USA). Input impedances were brought under 5 kΩ by careful scalp preparation. Data were analyzed by custom Analyzer 2.0 (Brain Products, Germany). Data were digitally filtered to remove frequencies above 40 Hz and below 0.1 Hz and were then separated into epochs time-locked to stimulus onset. Artifact rejection to remove high amplitude, high-frequency muscle noise and other irregular artifacts, were removed semi-automatically with the following criteria: max. amplitude of -100/100 μV; max. gradient of 50 μV/ms; low activity below 0,1 μV during 100ms or max. difference of 200 μV on adjacent points. The presence of eye-blink or eye-movement artifacts was not a criterion for rejection, and was corrected via ICA eye correction function, using restricted infomax ICA, with stopping weight change set to $1e^{-7}$. A baseline correction was applied using the 500ms prior to stimulus onset.

To group the different brain responses, we first grouped them by the explicit responses made by the subjects. After we made 3 groups of brands, using their relative position in the ranking of average classifications: the 20 first brands, the 20 brands having more indifferent answers and (classification between 65 and 80% of the maximum) and the third group of the 20 unknown brands. To the 20 first brands will be denominated in this paper by "the most preferred" brands, and the 20 with medial scores, will be denominated "the most indifferent" ones. The latter was the one used in most of the results presented here.

For frequency domain analysis, used to measure the asymmetries, the FFT analysis was conducted for each segment, normalized in the frequency range of 0.5-40 Hz with a Hanning window of 10%, after the segments were averaged and finally the information exported for statistical analysis. Electrodes were also averaged into eight clusters: frontal (left: Fp1, AF3, F7, F5; right: Fp2, AF4, F8, F6), centrofrontal (left: F3, F1, FC5, FC3, FC1; right: F4, F2, FC6, FC4, FC2), centroparietal (left: C3, C1, CP1, CP3, P1, P3; right: C4, C2, CP2, CP4, P2, P4), and occipitotemporal sites (left: TP7, T5, P5, PO7, PO3, O1; right: TP8, T6, P6, PO8, PO4, O2). Differences between anterior/posterior regions and left/right hemisphere were assessed with paired t-tests.

For the time domain analysis the event-related potentials (ERPs) for the first 1000 ms after stimulus presentation were calculated for each group and participant, for subsquent analysis of the most relevant ERP components: segments were averaged according to the groups they belonged to and a the area of the LPP component, between 400 and 600 ms was exported and analyzed for differences between the groups for all subjects, using paired t-tests for the electrodes in the medial centroparietal area (CZ, CPZ and PZ).

Finally, analysis in the spatial dimension was done using LORETA. First, time-average LORETA images for long periods of time were calculated in order to compare with fMRI data that does not have the same temporal resolution of the EEG. These images were obtained using statistical non-parametric mapping methodology (Nichols and Holmes, 2002). Then the ERPs were compared using a topographic analysis of variance (TANOVA, Strik et al., 1998) for the first 1000 ms. This method tests, with high time resolution, for differences between scalp potentials, using statistical comparisons carried out using the nonparametric randomization methodology, which corrects for multiple testing (time and electrodes). Only the periods of time that were significantly different between the groups of brands were used in the following step. In this last step, for all time segments longer than 10 ms, statistical analyses of functional LORETA images were performed. This step is justified because different scalp potentials can only be due to different neuronal source distributions.

LORETA

LORETA is a method developed by Pascual-Marqui and coworkers (1994) that computes a 3D distribution of electrically active neuronal sources in the brain as a current density value (A/m^2) based on the recorded scalp electric potential differences. This method calculates an estimated solution of the inverse problem based on the assumption that the smoothest of all possible activities is the most plausible one. This assumption is supported by electrophysiology, where neighboring neuronal populations show highly correlated activity (Haalmann & Vaadia, 1997). Due to the low spatial resolution property of this imaging method, it should be kept in mind that localization results might suffer from some uncertainty in terms of spatial extent. Source solution space was limited to cortical gray matter and hippocampi, according to the digitized probability atlas provided by the Montreal Neurologic Institute. In this version (of 4-11-2008, available at http://www.uzh.ch/keyinst/loreta.htm), the possible source solution is divided in 6329 voxels with dimension of 5 mm^3). LORETA has received important validation from studies combining with functional MRI (Vitacco, 2002) and with PET (Pizzagalli, 2004).

Results

Behavioral responses

The percentage of the average ratings given to brands and the respective average response time is presented in the Figure 2 and 3.

As it can be observed only the indifferent-rated and unknown have the expected values, being one fourth of the total responses. The positive rated brands have more than expected (39.8% vs. 25%) while the negative responses are much less than 25%. Due to the low number of negative rated brands some of the following analysis had to be discarded for this group.

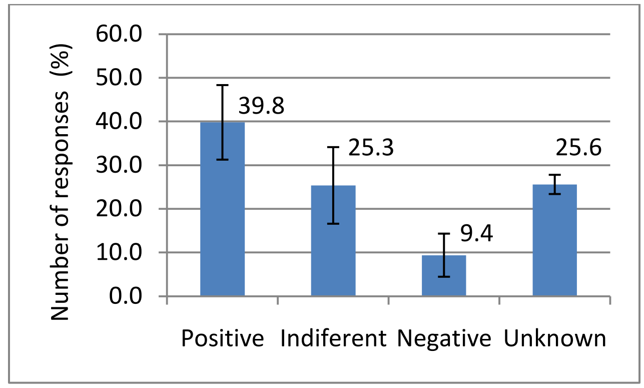

Figure 2 – Percentage of the number of responses for each possible rating, averaged for all subjects. The exact value and the std. dev. are presented.

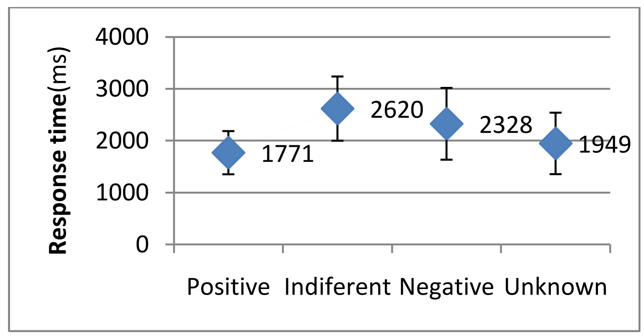

Figure 3 – Average of the response time for each possible rating in all subjects. Exact value and std. dev. are presented.

In the response time (RT) graphic it can be seen that positive brands have much smaller RTs in the classification task, aproximately, 1-s smaller than the slowest one: the indifferent brands.

Brain Responses (EEG)

The results of the asymmetries showed a pronounced right-hemisphere Alfa band power (p-value < 0.05) for every group of response ratings, meaning stronger left brain activation. Anterior/posterior asymmetry was also found for all classifications (p-value < 0.001)

In the ERP analysis (Figure 4), the mean potential measured in the LPP interval (400-600ms) revealed stronger activations in the centroparietal regions for the most preferred brands when compared with the most indifferent and the unknown brands (Table 1, 2).

Table 1 – Mean value of the potential in the LPP period (400-600 ms) for the most preferred brands and most indifferent, at locations where their differences are significant: frontal (AF3, AF4, F7, F5, F3, F1, FZ, F2, F4, F6, F8), centroparietal (CP1, CPZ, CP2, P1, PZ, P2) and occipital (PO3, POZ, PO4, O1, OZ, O2).

LPP (400-600ms)	Most preferred: avg (σ)	Most indifferent: avg (σ)	**mean difference** (p-value)
Frontal	-2,76 (1,89)	-2,20 (2,03)	-0,55 (0,013)
CentroParietal	3,05 (1,96)	2,43 (1,67)	0,62 (0,016)
Occipital	3,93 (2,95)	3,43 (3,20)	0,50 (0,035)

We can also see that most preferred brands elicited more activation in the frontal and occipital regions when compared to the most indifferent brands (Table 1).

On the other hand the unknown brands elicited more activation in the occipital cortex and frontocentral region during this period than the most preferred brands (Table 2).

Table 2 - Mean value of the potential in the LPP period (400-600 ms) for the most preferred brands and the unknown brands, at locations where their differences are significant: frontocentral (FZ, FCZ, CZ), centroparietal (CPZ, PZ) and occipital (OZ).

LPP (400-600ms)	Most preferred: avg (σ)	Unknown brands: avg (σ)	**mean difference** (p-value)
Frontocentral	-1,50 (1,90)	-3,14 (2,31)	1,64 (< 0,0001)
CentroParietal	3,02 (2,61)	2,27 (2,08)	0,75 (0,044)
Occipital	3,42 (3,53)	4,42 (3,90)	-1,01 (< 0,005)

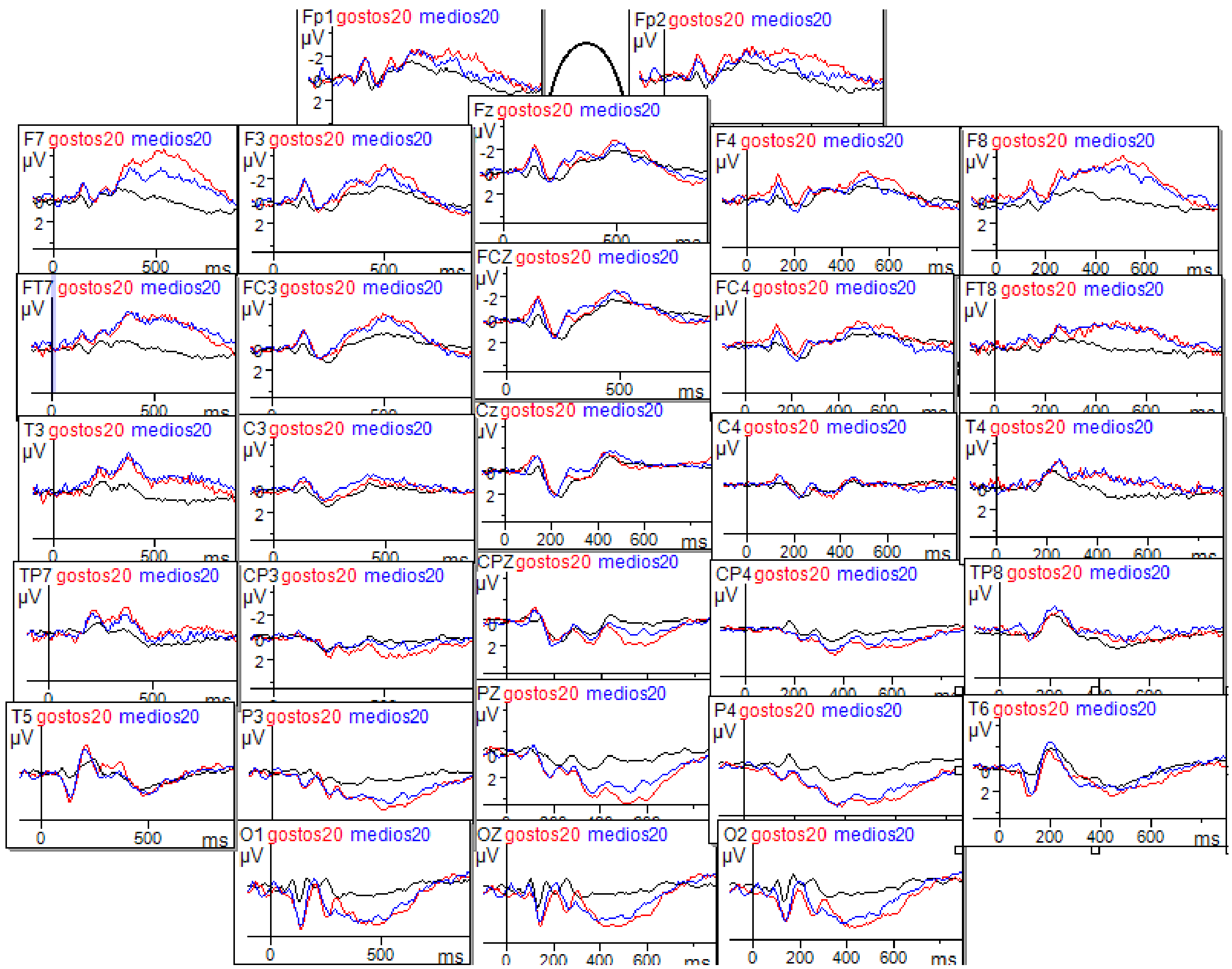

Figure 4 – ERP potentials of three different conditions: the non-emotional words or baseline (black line); the most preferred brands (red line) and the most indifferent brands (blue line) for the first second after the presentation of the stimulus.

In the following figures (Figure 5, 6 and 7) we can observe some of the most relevant results obtained with the LORETA method. In the Figure 5, we can verify qualitatively the differences between the most preferred brands and the most indifferent ones when compared with the baseline (non-emotional words) in the time period of the LPP. It's clear that the most preferred brands activate more the medial precuneus/posterior cingulate cortex and the left BA 7.

In the Figure 6, we present the results obtained from the direct comparison of the most preferred images and the most indifferent. Despite in the tANOVA many time-segments were identified as significant differences between the topographic maps of the two groups, when the sLORETA was calculated only the period approximately at 1600 ms revealed statistical significance (p-value <0.1). It corresponds to the middle frontal gyrus (-25, 60, 15). The other regions although not with statistical significance show similar results, the most preferred brands being more active in the frontal cortex.

The comparisons between the known brands (preferred/indifferent) and the unknown brands also revealed significant differences in the tANOVA analysis of the comparison of the topographic maps. Nonetheless, only the comparison between the most indifferent brands and the unknown revealed one time segment with statistical significant difference at 560 ms in the ventromedial prefrontal cortex (Figure 7) – p-value < 0.05.

Because of the lack of statistical significance when directly comparing the different groups, we based our discussions also in the indirect comparisons. The position and size of the *clusters* most relevant in the study resulting from the comparison of the groups with the baseline is described in the Table 3. From these results it is interesting to see that only the known brands activated the frontal cortex, the most indifferent activating more the ventral region (BA 11, 47) and the most preferred activating more the anterior rostral medial frontal region (BA 10).

Not shown here are the images resulted from the analysis of the temporal dynamics. In them we can see the different processes happening from the presentation of the stimulus to the decision of the classification. It can be seen first an activation around 100 ms after in the visual cortex (BA 17, 18 and 19); after an activation of the angular and the supramarginal gyrus around the 200 ms related to the reading of the name of the brand, and simultaneously with activations in the precuneus (BA 7, 31) related with attention and recognition memory.

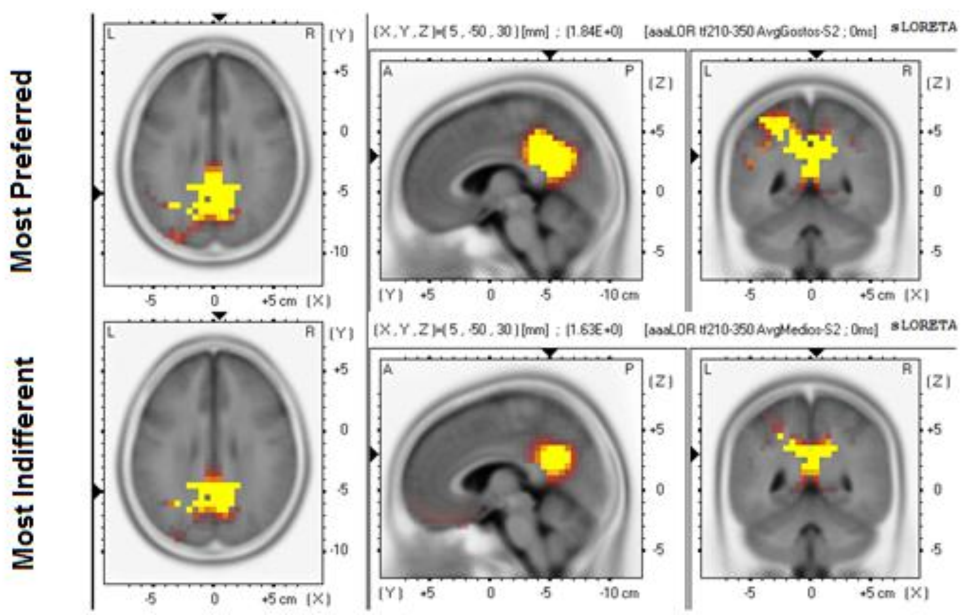

Figure 5 – Image of the results obtained using LORETA to assess the significant differences between the most preferred brands and the baseline (upper image) and between the most indifferent brands and the baseline (bottom image) in the time period between 400 and 600 ms. The yellow voxels have p < 0,01 and the red ones have p < 0,05. From left to right: transverse, sagittal and coronal planes.

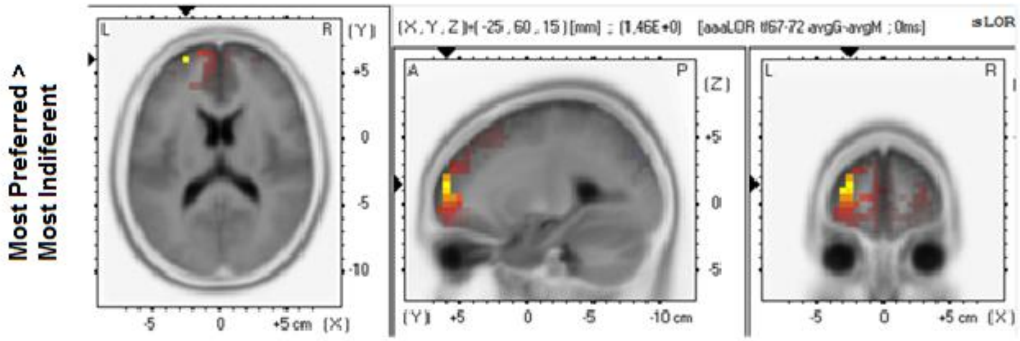

Figure 6 - Image of the result obtained using LORETA to assess the significant differences between the most preferred brands and the most indifferent brands in the time period approximately around 1600 ms. The yellow voxels have p < 0,1. From left to right: transverse, sagittal and coronal planes.

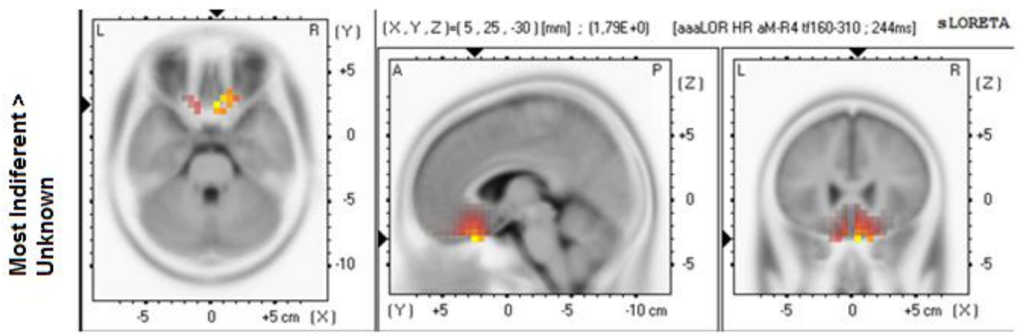

Figure 7 - Image of the result obtained using LORETA to assess the significant differences between the most indifferent brands and the unknown brands in the time period around 560 ms. The yellow voxels have p < 0,05. From left to right: transverse, sagittal and coronal planes.

Discussion

The results of the first research question suggest that all conditions had a stronger left involvement of brain structures, despite the fact that we expected to find a stronger asymmetry for the more positive-rated brands. This result may be due to the specific functions of the left hemisphere being preferencialy responsible for speaking and language (Purves, 2008) or suggest that all brands act as positive symbols that induce approach-related behavior.

The results of second research question corresponded to what we were expecting. The brands behaved the same way emotional images and words do (e.g. Pastor, 2008) in comparison to neutral ones. The larger LPP only for the preferred brands, suggests a stronger attention of the subject when observing his preferred brands and associated with the easiness to recognize these.

Studies of the LPP additionally found that images of more evolutionary significance (like erotic images) elicit greater LPP potentials than when compared with different images of the same emotional valence (Schupp, 2006). Also, Codispoti et al. (2006) verified that picture repetition doesn't affect the amplitude of the LPP of emotional pictures. Verifying that the same happens with brands, this confirms their importance and suggests that the numerous repetition of stimulus that are seen everyday don't diminish our attention to our preferred brands.

Table 3 – Detailed LORETA results of the significant differences in brain electrical activity in the time-average analysis (1-1000 ms) for the most preferred brands, most indifferent and unknown when compared with the baseline.

Time segment in ms	t-threshold	Activation in left hemisphere Cerebral region Brodmann areas (xyz-coordinates) [t-max] *nº of voxels*	Activation in medial regions Cerebral region Brodmann areas (xyz-coordinates) [t-max] *nº of voxels*
Most Preferred Brands 1 - 1000 ms	1.181	Precuneus 7 (-15, -63, 40) [1.47] 34 Frontal gyrus 10 (-21, 58, 0) [1.33] 37 Frontal gyrus 11 (-21, 58, 0) [1.33] 37	Precuneus 31 (-3, -61, 26) [1.45] 54 Frontal gyrus 10 (-11, 59, 2) [1.32] 18 Frontal gyrus 11 (-7, 63, -13) [1.25] 5 Posterior Cingulate 23/29/30/31 (-3, -57, 14) [1.34] 75
Most Indifferent Brands 1 - 1000 ms	1.333	Precuneus 7 (-22, -64, 40) [1.49] 9 Precuneus 31 (-16, -63, 25) [1.56] 18 Frontal gyrus 11 (-21, 43, -17) [1.48] 37 Posterior Cingulate 23/29/30/31 (-21, -66, 9) [1.51] 11 Orbital gyrus 47 (-18, 30, -23) [1.48] 10	Frontal gyrus 11 (-5, 35, -24) [1.50] 37
Unknown 1 - 1000 ms	1.1	Precuneus 7 (-14, -58, 43) [1.40] 45 Insula 13 (-25, -32, 17) [1.32] 23	Precuneus 31 (-4, -57, 29) [1.48] 43 Cingulate gyrus 24 (0, -6, 38) [1.29] 65 Posterior Cingulate 23/29/30/31 (-4, -51, 18) [1.33] 43

Numbers in parentheses give MNI coordinates (x, y, z) in mm, for $p < 0.01$. Brodmann areas correspond to MNI coordinates.

The importance of these results is made clear when answered the last research question by analyzing the results from LORETA. Applying the LORETA in the time period correspondent to the LPP, we were able to understand which regions are responsible for the greater electrical activity measured on the scalp for the most preferred brands. These regions are the posterior cingulate cortex and the precuneus both situated in the medial region of the brain. These areas are responsible for monitoring which informations are self-relevant (Binder, 2009) and keep the autobiographic memories (Cavanna, 2006). Deppe et al. (2005) observes greater activations in this region only for the first-choice brand, simultaneously with activations in the ventromedial fontral cortex, suggesting that are they are connected. These results are very interesting and similar to the results found in this study.

In the results of the time-average LORETA for the first second, it was clear that only the known brands provoked activations in the frontal cortex. Specifically the most indifferent brands caused activation in the orbital frontal cortex, being its medial area responsible for monitoring outcomes (Amodio & Frith, 2006). This may indicate that while assessing the indifferent brands, the subjects where assessing also their possible outcomes, evaluating if these brands might or might not bring rewards. The positive-rated brands have much weaker activations in this area, maybe because the subjects are much more conscious of their existing reward. Instead in these brands, the anterior rostral medial frontal cortex is the one activated (almost exclusively for these brands). This region is implicated in the self-knowledge, person perception and mentalizing (Amodio, 2006), suggesting the unique characteristics of the most preferred brands. Relating the two medial structures activated mostly for the preferred brands, we can guess the way the frontal medial cortex and the posterior medial cortex are connected: the posterior region raises our attention to the most important stimulus and keeps them in the memory of past self-related positive experiences, while the frontal region associates them as rewards, so that they can work as crucial cues to decision-making, and, finally, resulting in a successful strategic behavior.

We can then understand from Dittmar & Pepper (1994), the way the preferred brands helps us to construct our identity.

Conclusion

We conclude that logos are perceived in different ways, according to familiarity and preference. We found that the frontal cortex was exclusively activated for the familiar brands, revealing the importance of brands as meaningful symbols that convey a specific message about oneself or about our peers. Furthermore, preferred brands showed faster response times; had larger LPP, meaning they were given more attention and were more self-relevant. These brands were more active in the frontal cortex than indifferent brands when compared directly; and especially there was considerably more activation in the anterior rostral frontomedial cortex simultaneously with the precuneus and posterior cingulate, indicating the participation of the preferred brands in processes of person perception, self-knowledge and mentalizing (Amodio, 2006).

We achieved our objectives of this exploratory study and reinforce the importance of the EEG technique in future studies of neuromarketing.

Future

The lack of statistical significance in some results may be due to small sample used. And to reduce the variability, only male participants were accepted. We suggest that future studies should have a larger number of participants and of both genders.

We propose another method to study brands' perception which would be to listen to the brands name instead of watching visually the logo. This would permit to study more uniformly the different brands as well as separate the perception of the brand from the perception of the logo.

Finally we advise the use of more complete questionnaires, like the familiarity test.

References

Aaker, David A. (1996), *Building Strong Brands*. New York, USA: The Free Press.
Ambler, Tim, Andreas Ioannides and Steven Rose (2000), "Brands on the Brain: Neuro-Images of Advertising" *Business Strategy Review*, 11 (3), 17-30.
Amodio, David M., & Frith, Chris D. (2006), "Meeting of minds: The medial frontal cortex and social cognition" *Nature Reviews Neuroscience*, 7, 268-277.
Bartholow, Bruce D., and David M. Amodio (2009), "Using event-related brain potentials in social psychological research", in *Methods in social neuroscience*, Eddie Harmon- Jones and Jennifer S. Beer, ed. New York: The Guildford Press, 198-232.
Astolfi, Laura, Giovanni Vecchiato, Fabrizio De Vico Fallani, Serenella Salinari, Febo Cincotti, Fabio Aloise, Donatella Mattia, Maria Grazia Marciani, Luigi Bianchi, Ramon Soranzo, and Fabio Babiloni (2009), "The track of brain activity during the observation of tv commercials with the high-resolution EEG technology" *Computational Intelligence and Neuroscience*, 2009, 1-7.
Binder, Marc D., Nobutaka Hirokawa, and Uwe Windhorst (2009), *Encyclopedia of Neuroscience*. Berlin, Germany: Springer.
Camerer, Colin, George Loewenstein, and Drazen Prelec (2005), "Neuroeconomics: How neuroscience can inform economics" *Journal of Economic Literature*, 43 (1), 9-64.
——— (2008), "Neuroeconomics: Opening the Gray Box" Neuron, 60, 416-419.
Cavanna, Andrea E., and Michael R. Trimble (2006) "The precuneus: a review of its functional anatomy and behavioural correlates" *Brain*, 129, 564-583.
Codispoti, Maurizio, Vera Ferrari, and Margaret M. Bradley (2006), "Repetition and Event-related Potentials: Distinguishing Early and Late Processes in Affective Picture Perception" *Journal of Cognitive Neuroscience*, 19(4), 577-586.
Cuthbert, Bruce N., Harald T Schupp, Margaret M. Bradley, Niels Birbaumer, and Peter J. Lang (2000), "Brain potentials in affective picture processing: covariation with autonomic arousal and affective report" *Biological Psychology*, 52, 95-111.
António Damásio (1998), "Emotion in the perspective of an integrated nervous system" *Brain Researchs Reviews*, 26, 83-86.
Deppe, Michael, Wolfram Schwindt, Harald Kugel, Hilke Plassmann, and Peter Kenning (2005a), "Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision making" *Journal of Neuroimaging*, 15, 171-182.
Dittmar, H., & Pepper, L. (1994), "To have is to be: materialism and person perception in workingclass and middle-class British adolescents" *Journal of Economic Psychology*, *15*(2), 233-251
Elliott, Richard, & Wattanasuwan, K. (1998), "Brands as symbolic resources for the construction of identity" *International Journal of Advertising*, *17*(2), 131-144.
Erk, Susanne, Spitzer, M., Wunderlich, A. P., Galley, L. & Walter, H. (2002) "Cultural objects modulate reward circuitry" *Neuroreport*, 13, 2499-2503.
Haalmann, I., Vaadia, E., (1997), "Dynamics of neuronal interactions: relation to behavior, firing rates, and distance between neurons" *Human Brain Mapping*, 5, 249–253.
Harmon-Jones, Eddie, and Carly K. Peterson (2009), "Electroencephalographic methods in social and personality psychology", in *Methods in social neuroscience*, Eddie Harmon-Jones and Jennifer S. Beer, ed. New York: The Guildford Press, 171-197.
Hubert, Mirja and Peter Kenning (2008) "A current overview of consumer neuroscience" *Journal of Consumer Behaviour*, 7 (July-October), 272-292.
——— (2010), "Does neuroeconomics give new impetus to economic and consumer research?" *Journal of Economic Psychology*.
Knutson B, Rick S, Wimmer GE, Prelec D, Loewenstein, G. (2007) "Neural predictors of purchase" *Neuron*, 53(1), 147-156.
Lee, Nick, Amanda J. Broderick and Laura Chamberlain (2007), "What is 'neuromarketing'? A discussion and agenda for future

research" *International Journal of Psychophysiology*, 63, 199-204.

Maddock, R. J., Garrett A. S., and Buonocore M. H. (2003), "Posterior cingulate cortex activation by emotional words: fMRI evidence from a valence decision task" *Human Brain Mapping*, 18(1), 30-41.

Marci, Carl D. (2008), "Minding the gap: the evolving relationships between affective neuroscience and advertising research" *International Journal of Advertising*, 27 (3), 473-475.

McClure, Samuel M., Jian Li, Damon Tomlin, Kim S. Cypert, Latané M. Montague, and P. Read Montague (2004) *Neuron*, 44, 379-387.

Nichols, T.E., Holmes, A.P. (2002), "Nonparametric permutation tests for functional neuroimaging: a primer with examples" *Human Brain Mapping*, 15, 1–25.

Ohme, Rafal, Dawid Wiener, Dorota Reykowska, and Anna Choromanska (2009), "Analysis of Neurophysiological reactions to advertising stimuli by means of EEG and Galvanic Skin Response measures" *Journal of Neuroscience, Psychology, and Economics*, 2 (1) 21-31.

Pascual-Marqui, R.D., Michel, C.M., Lehmann, D., (1994), "Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain" *International Journal of Psychophysiology*, 18, 49–65.

Pizzagalli, D.A., Oakes, T.R., Fox, A.S., Chung, M.K., Larson, C.L., Abercrombie, H.C., Schaefer, S.M., Benca, R.M., Davidson, R.J., (2004), "Functional but not structural subgenual prefrontal cortex abnormalities in melancholia" *Mol. Psychiatry* 9, 325-393.

Plassmann, Hilke, Peter Kenning, Michael Deppe, Harald Kugel, and Wolfram Schwindt (2008), "How choice ambiguity modulates activity in brain areas representing brand preference: evidence from consumer neuroscience" *Journal of Consumer Behaviour*, 7 (July-October), 360-367.

Purves, Dale, David Fitzpatrick, George J. Augustine, and LC Katz (2008), *Neuroscience.* Sunderland (MA), USA: Sinauer, Inc.

Santos, José P., Daniela Seixas, Sofia Brandão, and Luiz Moutinho (2008), "Neural Correlates of Emotional and Symbolic Brands' Content" paper presented at the 2008 ConNEcs - Conference on NeuroEconomics, Copenhagen Business School, Copenhagen, Denmark (March 27-31).

Schaefer, Michael, Harald Berens, Hans-Jochen Heinze, and Michael Rotte (2006), "Neural correlates of culturally familiar brands of car manufacturers" *NeuroImage*, 31, 861-865.

Schupp, Harald T., Tobias Flaisch, Jessica Stockburger, and Markus Junghofer (2006), "Emotion and attention: event-related brain potential studies" Progress in Brain Research, 156(2), 31-51.

Strik,W.K., Fallgatter, A.J., Brandeis, D., Pascual-Marqui, R.D., (1998), "Threedimensional tomography of event-related potentials during response inhibition: evidence for phasic frontal lobe activation". *Electroencephalogr. Clin. Neurophysiol*, 108, 406–413.

Vitacco, D.,Brandeis, D., Pascual-Marqui,R., Martin, E., (2002), "Correspondence of event-related potential tomography and functional magnetic resonance imaging during language processing" *Human Brain Mapping*, 17, 4–12.