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Use of EEG as a Neuroscientific Approach to Advertising Research

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Abstract

This exploratory work, in the neuromarketing field, intends to give an overview of the tools that neuroscience has brought to marketing, how they can help consumer research and to clarify results that have been presented to the academic community but still deserve further validation. We also studied how ads are perceived in the brain (Advertising Research) and tried to “bring to light” what private corporations have been doing in neuromarketing.

In recent years research in neuromarketing has been multiplying. We revised some of that recent work, and the cornerstones of neuromarketing research. Questions about validity and reliability of some works have been raised. Doubts about the utility of neurosciences in marketing still persist, and fear about whether neuroscience can be used in an invasive way against privacy principles still endures. We intend to give some guidelines for future research and present results that can help validate in this field the neuroscience tool we are using, the electroencephalogram (EEG).

We recorded the EEG of 20 participants, all men, right-handed, and in between 20-29 years, while they were viewing 30 TV commercials, divided into 5 blocks that appeared in random order. We analysed the results by doing frequency analysis and a LORETA analysis.

We concluded that the ad that received better score on the questionnaire had more emotional processing neural circuits activated than the ad that received worse scores, and that EEG is a valid technique in Advertising Research. However, more research is needed for the study of the brand itself and how it influences the perception of an ad.

Keywords: Neuromarketing; Consumer Research; Advertising Research; ads; electroencephalogram (EEG); LORETA

Resumo

Esta tese é um trabalho exploratório, no campo do neuromarketing, que pretende dar uma visão geral das ferramentas que a neurociência tem trazido para o Marketing, e como eles podem ajudar no "*consumer research*" esclarecendo resultados que foram apresentados à comunidade académica, tentando dar-lhes uma validação adicional. Estudámos também como os anúncios são assimilados pelo cérebro (Advertising Research) tentando esclarecer o que as empresas privadas têm vindo a fazer na área do neuromarketing.

Nos últimos anos, investigações em neuromarketing têm-se multiplicado. Revimos alguns dos trabalhos mais recentes e os estudos que são considerados os alicerces da investigação no neuromarketing. Têm sido levantadas perguntas sobre a validade, a fiabilidade de algumas obras. As dúvidas sobre a utilidade das neurociências nesta área ainda persistem, e o medo de que a neurociência possa ser usada de uma maneira invasiva aos princípios de privacidade ainda perdura. Pretendemos fornecer algumas sugestões para futuras pesquisas e apresentar resultados que possam ajudar a validar, neste domínio, a ferramenta de neurociência que usamos, o eletroencefalograma (EEG).

Registámos o EEG de 20 participantes, todos homens, destros, e entre 20-29 anos, enquanto eles viam 30 anúncios de televisão, divididos em cinco blocos que apareciam aleatoriamente. Foram analisados os resultados recorrendo a uma análise de frequências e utilizando o método LORETA.

Concluiu-se que o anúncio que recebeu melhor pontuação activou mais os circuitos neurais responsáveis pela emoção do que o anúncio com pior pontuação, e que o EEG demonstrou ser uma técnica válida em Advertising Research. Contudo, mais estudos são necessários no estudo da marca e sua influência num anúncio.

Palavras-Chave: Neuromarketing; Consumer Research; Advertising Research; anúncios; electroencefalograma (EEG); LORETA

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Abbreviations

ACC	anterior cingulate cortex
ANS	automatic nervous system
BA	Brodmann area
CNS	central nervous system
CT	computed tomography
DLPFC	dorsolateral prefrontal cortex
EEG	electroencephalogram
EOG	electrooculogram
ERD	event related desynchronization
ERP	event related potential
ERS	event related synchronization
FIR	finite impulse response
fMRI	functional magnetic resonance imaging
HERA	hemispheric encoding/retrieval asymmetry
ICA	independent component analysis
IIR	infinite impulse response
MAC	memory-affect-cognition
MEG	magnetoencephalography
MFC	medial frontal cortex
PET	positron emission tomography
SNS	somatic nervous system
SSPT	steady-state probe topography
SSVEP	steady-state visually evoked potential
VMPFC	ventromedial prefrontal cortex
WRO	weighted resolution optimization

1. Introduction

In recent years neuroscience has been experiencing a rapid development, as new brain imaging techniques appear, and old ones improve (Lee, Broderick et al. 2007).

In this thesis we intended to apply a well known neuroscience technique into Marketing, which is becoming commonly known as the field of Neuromarketing. The focus of the study is on how brain responds during the visualization of short advertising movies. Using the electroencephalography (EEG) we will study the main brain regions being used during the presentation of the stimulus, and also the frequency bands.

We may wonder about how useful it is to use neuroscience knowledge in marketing, what can neuroscience add to marketing, or why use this specific technique. These questions are defined in the beginning of the thesis and are key marks for the development of the goals of this particular study.

This paper is divided into four major chapters: introduction, experimental design, results and discussion, and conclusion and future developments. In this introduction, theory background will be presented, starting with fundamentals of neuromarketing and its history, following with the presentation of techniques used in neuroscience, especially the EEG, and ending with a review of previous studies in neuromarketing. In the experimental design chapter, the paradigm of this study will be explained and discussed. In the results and discussion chapter, we will interpret and fundament the results obtained. In the chapter conclusions and future developments we will present the conclusions of this work, giving a brief summary of the worth mentioning results, and give a brief insight view of the issues we encountered along this study and how we solve them and gave some guidelines for future researches.

1.1 Neuromarketing – What can neuroscience add to marketing?

Before answering this question we should first present some key definitions.

Marketing is a:

"*social and managerial process by which individuals and organizations obtain what they need and want through creating and exchanging products and value with each other*" (Kotler, Armstrong et al. 2008).

In early days, marketing was considered to be only advertising, distribution and selling of an industry (Adcock, Halborg et al. 2001; Kotler and Keller 2008). Nowadays, because of the use of other academic areas like social sciences, psychology, sociology, mathematics, economics and more recently neurosciences, it evolved and it is recognized as a more comprehensive science. Contemporary approaches give different dimension of marketing such as: relationship marketing where customer has the lead role; business marketing, and social marketing where society benefits are what matters (Adcock, Halborg et al. 2001). With the current decline of advertising power and

brand's rising competition, the new marketing challenge is how to create consumer value while receiving value in return (Engel, Blackwell et al. 1995).

Neuromarketing is a branch of the general field of neuroeconomics, which is an interdisciplinary field that combines economics, neuroscience and also psychology, to study the brain function in decision-making situations (Kenning and Plassmann 2005).

Neuroscience intends to gather knowledge about the structure and function of the brain. A specific branch of neuroscience is cognitive neuroscience that tries to understand the neural mechanisms behind thoughts like reasoning, emotion, memory, decision making, and so on. This field when applied in marketing can help in notions of positioning, hierarchy of effects, and brand loyalty (Perrachione and Perrachione 2008). Using advances in neuroscience, researchers can obtain information about human brain's response to marketing stimuli (P. Renvoisé and Morin 2007), without simply relying on subjective reports given by the participant (Hubert and Kenning 2008; Murphy, Illes et al. 2008).

1.1.1 Brief review of neuroeconomics and neuromarketing history

Despite all the advances in neuroimaging, marketing research is still unaware of its huge potential. In fact, this has caused some controversy along its still brief history, on the basis that neuromarketing is only interested in "finding the buy button in the brain" (Lee, Broderick et al. 2007). Because of that, while neuroeconomics for the last two decades have been importing knowledge from psychology ("*Behavioural economics*") and neuroscience, neuromarketing only very recently did so (Camerer, Loewenstein et al. 2005).

As it was said before, neuromarketing can be considered a branch of neuroeconomics and, more importantly, neuroeconomics has a longer history. Neuroeconomics has its story built upon behavioural economics which, by introducing psychology foundations into economy, intends to improve the field of economics and its theories (Camerer and Loewenstein 2004). It was in the 1970's that psychology and economics were merged, by Kahneman and Smith, creating Behavioural economics (Deppe, Schwindt et al. 2005).

But not even neuroeconomics was free of controversy and rejection. Back in the 1940's, concepts like ordinal utility and revealed preference were at the base of economic models, eliminating the importance of feelings. Economics was built upon the assumption that the brain was the ultimate "black box" (Camerer, Loewenstein et al. 2005; Camerer 2008). Paradoxically, neoclassical economics had some ideas of today's behavioural economics (Camerer and Loewenstein 2004). With the neoclassical revolution those ideas were slowly being rejected from economics, mainly because at that time psychology was not regarded as a discipline and emotions were still undefined. Today modern economy is based on Bayesian maximization of expected utility, in which humans (*homo economicus*) are equipped with unlimited knowledge, time and information-processing power (Bechara and Damasio 2005). However, new neuroscience evidence suggests that emotional processing is important in decision-making. The somatic marker hypothesis, formulated by Antonio Damasio, is a response to the rejection of emotion in economics, and proposes that man is not completely rational,

he too has emotions and our decisions are not only guided by knowledge and reasoning. In fact emotion can be beneficial in decision-making when it's integral to the task, and decision with uncertainty has different neural circuits than with certainty (Damasio and Sutherland 1995; Bechara and Damasio 2005).

The recent history of neuromarketing goes back to the end of the 1990's when Gerry Zaltman used fMRI as a marketing tool, but only in 2002 the word "neuromarketing" was coined by Professor Ale Smidts (Lewis and Bridger 2005). Only in 2004 did the first Neuromarketing conference take place in Houston. Nowadays, Neuromarketing research goes from response to products, brands and advertising, in consumer behaviour and in marketing exchanges. In fact consumer behaviour can be defined as:

"*those activities directly involved in obtaining, consuming, and disposing of products and services, including the decision processes that precede and follow these actions*" (Engel, Blackwell et al. 1995).

One can notice how much attention researchers are giving to the product/consumer interaction and to factors such as brands in affective decision-making.

However, we can see how little has been done in this field and how much can yet be done. In fact there is another problem that has been, certainly, contributing to the discredit of neuromarketing. Not only general public and academic research have been somehow overly concerned about the ethical issues that this field brings, but some commercial enterprises that use neuroscience tools in marketing research do not bring to light all the procedures, methodologies, and results, which also gives rise to suspicion and a negative view among the academic community. Sometimes they even may give simplistic answers and results to give rise to future private profit (Illes and Bird 2006; Murphy, Illes et al. 2008).

So we propose since the beginning of this thesis to try and reproduce what some private sectors have been doing with not completely described methodologies, but presenting completely described procedures, so that in the future partnerships between private and academic sectors can occur and more credibility can be given to neuromarketing research. To achieve this, we will study a specific area of marketing using neuroscience, advertising with TV commercials as the medium. We will also try to infer about the perception of brands' logo or name during the visualization of ads, and we will respect the two major categories of ethical issues that neurosciences techniques can raise: safety of the subject and protection against exploitation done by the research, marketing, and deployment of neuromarketing as well as protection of the consumer autonomy (Murphy, Illes et al. 2008).

There are more criticism and limitations of neuroscience that one should be aware when doing such a study. We should be aware of the complexity of the human brain when interpreting the results. Sometimes, studies do not have a great robustness (i.e. reliability issues), for example when the number of participants is too low, leading to reported differences in results for different studies with the same procedure (Hubert and Kenning 2008). The variables in marketing are numerous, not to mention

the variability between participants, making us wonder if we can control all (Lee, Broderick et al. 2007). Furthermore, some brain imaging techniques do not provide a natural and realistic environment, having instead to be prepared in a medical environment, which can affect the collected data relative to consumer decisions (i.e. external validity issues). Currently the number of published articles about neuromarketing has been increasing, but can it be possible to produce coherent collective conclusions from all the scattered studies (Plassmann, Ambler et al. 2007)?

1.1.2 Neuromarketing importance

Despite all criticism, neuromarketing has a large "space" to grow. As stated previously, emotions do indeed influence human decisions in economics as well as in marketing. Thus the application of neurosciences in marketing is huge and has its advantages. First, until neuromarketing appeared, the traditional methods used by marketing were mostly based on self-assessment measures that rely on the ability and willingness of the participant to report correctly their attitudes, their behaviours, or how they feel, which are less powerful and explanatory than once believed (Fugate 2007). Moreover, many effects that are determinant in decision and influence behaviour are not perceived consciously making them impossible to report. Neuroscience methods can go deeper to the underlying biological and chemical processes which will give us a better view of psychological and behavioural processes, allowing finally to have a more direct view into the ultimate "black box" (Hubert and Kenning 2008; Harmon-Jones and Beer 2009). Thirdly, the participants cannot bias or influence the results, as they have little to no influence on the measurement of brain activity (Camerer, Loewenstein et al. 2005; Hubert and Kenning 2008). Furthermore, physiological responses can be collected at the moment of the experience instead of some traditional methods where the results are obtained after the stimulus (Lee, Broderick et al. 2007). And at last, new theories about brain mechanisms can be studied and existing ones can be reassessed. Ultimately, neuroscience's goal is to understand how human brain produces behaviour (Glimcher 2004), and neuroeconomic and neuromarketing's goal is helping out in what classical economics theories have failed to explain: how human behaviour, their characteristics and the way they think influence decision-making.

1.2 Neuroscience techniques

Marketing research needs more precise and unbiased measurements of the psychological processes. As mentioned, one of the most important reasons for using neuroscience techniques is to overcome the inability of consumers to fully express their feelings and thoughts through self-reported verbal or written measures. We will introduce ten psychophysiological techniques that have been appearing in published studies: three central nervous system (CNS) measures, five automatic nervous system (ANS) measures, and two somatic nervous system (SNS) measures (Wang and Minor 2008).

Firstly, what does psychophysiology mean? Psychophysiology is an interdisciplinary subject that incorporates findings of physiology (neurophysiology), and psychology, so it is a science that is concerned with understanding the relationship between behaviour and physiological processes happening in the brain (Kroeber-Riel 1979; Wang and Minor 2008).

The CNS measures are the non hemispheric brain wave analysis, and the hemispheric lateralization and brain imaging analysis. The ANS measures are pupillary response, electrodermal analysis, voice pitch analysis, heart rate response, and vascular activity. And the SNS measures are the facial muscle activity and eye movement analysis. These techniques have been used in marketing research since the 1960's, when the most used were the pupillary response and electrodermal analysis. In the present, non hemispheric brain wave, hemispheric lateralization, electrodermal, facial muscle activity, and eye movement analysis are still being used, but it is heart rate and brain imaging analysis that have been experiencing a growing number of applications in marketing research (Kroeber-Riel 1979; Wang and Minor 2008).

1.2.1 Brief review of psychophysiological techniques

Concerning the objectives of the study, and what would be accessible to us, we chose the most suited psychophysiological techniques for this thesis. According to experts on psychophysiology the appropriate use of these techniques depends on how well we understand the working mechanism, and how we want cognitive and affective processes to be measured (Wang and Minor 2008). They further suggest criteria we should consider when choosing the measurement technique. For example, Plummer (1972) suggests seven criteria, that include sensitivity, validity, reliability, independence of measures, comprehensiveness, relationship to other tests, and acceptability, which we should examine before proceeding with the research. Two of the most important criteria are validity and reliability. Reliability can be defined as how consistently does a technique assess what it is measuring. Conversely, validity means how accurately a test measures what it says it is measuring (Carducci 2009). A brief review of all the psychophysiological techniques will be introduced next, ending with the ones that will be used in this study.

Pupillary response was one of the earliest psychophysiological techniques to be used. It measures changes in a person's pupil size. In early studies, pupillary response was used as an indicator of affective responses (arousal and pleasure), and as a measure of evaluating the effectiveness of an advertisement. Despite its simplicity in applicability, questions about the validity were raised, especially about which psychological process was being demonstrated: attention, arousal, pleasure, memory, and so on (Stewart and Furse 1982; Wang and Minor 2008).

With **electrodermal analysis** we can measure the resistance or conductance to passing current through human skin, by simply using two electrodes. Changes in resistance due to the sweat glands can be a result of interest, arousal, pleasure, or other physical and emotional states. This technique has been extensively used in the study of attention, arousal, anxiety, and warmth as affective processes. For example, during studies of anxiety the conductance of the skin decreases. Other studies revealed that resistance/conductance of the skin is linearly correlated with arousal, and is a sign of emotional or cognitive responses (Mandryk, Inkpen et al. 2006). Though reliable and valid for measures of arousal, for measures of attention, and as indicator of warmth as an affective process, studies have shown that electrodermal analysis is not valid. Some cautions should be taken with this technique, especially with electrode placement. The placement site should be carefully chosen to not bias the results (Gerald Matthews 2003; Wang and Minor 2008; Carducci 2009).

Voice pitch analysis studies the fluctuations in human speech that can indicate a person's affective response to the stimuli. It has been shown to be more valid, reliable, and sensitive than verbal measures in marketing research. This technique has two advantages over other psychophysiological methods. First, the equipment is much simpler, only an audio recorder device is necessary, which in turn enables the second advantage, the natural experimenting environment. However, validating evidence is still necessary from future researches. Although nowadays use of voice pitch analysis seems to be quite inexistent, there is still space for this technique as new equipment and software programs made it possible to digitally record the voice and analyse it with much more powerful tools (Wang and Minor 2008).

Heart rate response is a branch of cardiovascular analysis, measured by an electrocardiogram (EKG) that records the electrical discharges when muscle contraction of the heart happens. Heart rate changes can be associated to arousal and excitement emotions, as well as cardiac disorders. Studies have confirmed that heart rate response is valid and sensitive when measuring pleasant or unpleasant responses, cognitive processes such as attention, and capable of predicting recall and memory. Even so, researchers should be careful when making generalizations with this technique and be meticulous when explaining and interpreting heart rate changes (Wang and Minor 2008; Carducci 2009).

Another branch of cardiovascular analysis is vascular activity that records changes in blood pressure, blood volume or pulse volume. Previous researches have used vascular activity to measure arousal, finding it highly correlated with skin conductance. However, validity and reliability is yet to be confirmed, as vascular activity can be a result of other psychophysiological processes, like pleasure, and memory. These issues should deserve special attention in future studies (Wang and Minor 2008).

Facial muscle activity is usually measured by electromyography (EMG) that registers the electrical signal caused by contraction of the facial muscles. This method is, unlike the previous ones, a voluntary physiological indicator created by the somatic nervous system. Facial muscle activity has proven to be more reliable than self-report measures, making it attractive in studies of attention, fatigue, and identifying the directions of affective responses (pleasure/displeasure, positive/negative affect). It has become accepted for research of affective reactions to a variety of visual, auditory, gustatory, and olfactory emotional stimuli, emotional faces, drugs, and so on. Some problems concerning facial EMG are the produced electrical signals that can be influenced by participant's movement, the electrode placement, and the problem of identifying specific emotional expressions which is still dubious (Mandryk, Inkpen et al. 2006; Wang and Minor 2008; Hess 2009).

Eye movement measures the number of fixations or the dwell time of the eyes during exposure to external stimuli. Researchers can find the moments of a stimulus that receives voluntary or involuntary attention by examining eye patterns. Eye movements are believed to be related to attention, memory and information processing; however this is questioned because studies have not yet established a physiological basis for this technique. For example, the number of fixations per second was used in studies as an accurate indicator of cognition activity (attention to advertising), where higher number of

fixations indicated higher attention. Validity and reliability is still required and, moreover, this technique restricts the recruitment of people with certain eye problems (Wang and Minor 2008; Heath 2009).

The next three psychophysiological techniques are the most important for this thesis: the CNS measures. The first is **non hemispheric brain wave analysis**, measuring the variations in frequency of electrical brain waves, like alpha waves versus beta waves or versus theta waves. These may be used to study consumer's cognition (e.g., memory, attention), and arousal or pleasure. Researchers have also been using these techniques focusing on consumer's immediate response to variations in advertising and branding. Reliability and validity of this method is still in question, but the combination with ANS or SNS measures could be the solution (Wang and Minor 2008).

The second CNS measure is **hemispheric lateralization** that studies the differences between left and right brain hemispheres during exposure to external stimuli. Hemispheric lateralization is one of the oldest and more used CNS measures, and it has been suggest that whether the information is processed in the left or right side of the brain will influence the information acquisition and the decision of the subject. It was already used for studying hemispheric differences related to arousal, pleasure, memory and information processing. However, many researchers are sceptic about the reliability and validity of this measure, one of the reasons being that the findings were not easily generalized. Another reason were the problems concerning the experimental setting: when using EEG, the electrode placement can influence the results obtained, so one should be very careful when doing so, and record which placement is being used and its taxonomy (Wang and Minor 2008). One study using this type of measure was in Rossiter et al. (2001), which concluded that measuring the relative patterns of activation of left and right hemispheres in the pre-frontal area can give information about the potential of a TV commercial, and that encoding into long-term memory of visual scenes happens in the left hemisphere. Another research worth mention is Ohme, Reykowska et al. (2010). The aim of that study was to compare parts of TV commercials that were identified as emotional part scenes, product-benefits scenes, product scenes, and brand scenes. They concluded that one of the commercials had left hemisphere dominance, which according to the model used (Davidson model) indicated an approach reaction. They also concluded that frontal asymmetry measurement could be a potential diagnostic tool for predicting if advertisements will produce an approach-related reaction rather than withdrawal.

The last method is **brain imaging analysis** that, using neuroscience techniques, investigates brain activities by capturing brain images. The neuroscience technologies used are functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and Magnetoencephalography (MEG). These recent techniques, by monitoring magnetic activity or radioactive patterns, can give images of the brain with high spatial resolution, and with a sufficient temporal resolution for non static stimuli. The PET using an X-ray scanning detects at which rate brain cells use energy, where the faster the rate means those cell have more activity. The fMRI measures the magnetic properties of blood before and after oxygen is used by the brain cells, with reference to an external magnetic field. More activation of the brain cells reflects on a bigger difference between the magnetic properties (Carducci 2009). Since the 90's, fMRI has been one of the most used brain imaging technologies in

the research of product preferences, advertising, brand loyalty, pleasure or arousal, information processing, memory, and other phenomena. It was considered to be more accurate than other methods in marketing, like surveys, and more effective than most of the other psychophysiological techniques. Brain imaging analysis has been demonstrated to be valid and reliable in measuring cognitive and affective responses. For example, McClure, Li et al. (2004) concluded that the hippocampus and DLPFC are the principal brain regions responsible for affective brain activities, and that together with cognitive brain activities could explain brand preferences. Despite the validity and reliability of brain imaging analysis, ethical issues are the downside of these techniques. As mentioned before, these techniques can be considered to be an invasion of individual privacy, raising ethical dilemmas. So we should be careful when using it and try to preserve the subject's privacy and avoid ethical issues (Wang and Minor 2008). Beside fMRI, PET and MEG, EEG can be used too in brain imaging analysis. Combining EEG with fMRI should yield the best of the two techniques, giving the temporal resolution of EEG and the spatial resolution of fMRI. But EEG can be used alone, particularly with recourse to more recent methods such as the high-resolution EEG. One interesting research combined high-resolution EEG and steady-state somatosensory evoked potentials (SSSEPs) technique obtaining similar results as studies using fMRI and MEG, and concluded that this tool could be used in future research in decision-making and recognition tasks (Astolfi, Fallani et al. 2009). The researchers showed to 10 subjects a documentary interrupted three times with blocks of six TV commercials, with a total of 18 commercials. After ten days, the subjects were interviewed again for spontaneous recall of ads they remember, dividing then the EEG data of the videos into two groups (the ones spontaneously remembered, and the ones forgotten). They concluded that during visualization of the remembered videos posterior parietal cortices and prefrontal areas were relatively more activated, which was compatible with previous results with fMRI.

In the present study we want to use high resolution EEG with the three CNS measures (non hemispheric brain wave analysis, hemispheric lateralization and brain imaging analysis) expecting to validate this technique and three measures, with special attention to brain imaging analysis, that typically is not used with EEG.

But why use EEG? While in non hemispheric brain wave analysis and hemispheric lateralization EEG, Steady-State Probe Topography (SSPT) and MEG are the ones used, when it comes to brain imaging analysis fMRI, PET and MEG are the best suited.

In spite of this EEG has been used in marketing for over 35 years (Krugman 1971; Murphy, Illes et al. 2008) and there is still much to discover about the applicability of this technique. The advantages of the use of the EEG are its high time resolution of milliseconds (Nunez and Srinivasan 2006), its ability to measure electrical activity continuously, its safety, its cheap cost compared to the other techniques, and the fact that it is more portable. On the other hand, it is limited in its volumetric spatial resolution, its inability to localize intracranial generators from scalp surface, reduced sensitivity for subcortical generators and volume conductor mixing of potentials (Leal 2008).

But today EEG devices are available with 32, 64, 128 and even 256 electrodes that reduce the inter-electrode distance to 2-3 cm, and new and more powerful processing and analysing software is available, which improve spatial sampling and lead to new analysing methods that aim to further improve the spatial resolution of EEG (historical review and state of art of EEG will be discussed further on).

Because of the EEG advantages discussed earlier, and because of this new opportunity of high-resolution EEG methods, this neuroscience technique was the chosen one.

1.2.2 Historical Review of Electroencephalography

The first time that electrical activity was recorded from the scalp of a human was in 1929 by the German physiologist and psychiatrist Hans Berger (1873-1941). But the study of electrical brain activity begins with Richard Caton (1842-1926) in 1875. Both Swartz and Lopes Da Silva give a full description of the history of EEG (Swartz 1998; Niedermeyer and Lopes da Silva 2005)).

The studies of Berger on human EEG started in 1920, and the instrumentation used begin with a string galvanometer (1910), first with the Einthoven type, then with the smaller Edelmann model, and after with the larger Edelmann model. In 1929, Berger used a Siemens double coil galvanometer and nonpolarizable pad electrodes to record the human EEG. With these studies, Berger was able to identify alpha waves, the alpha rhythm and alpha blocking response, fluctuations of consciousness, EEG recordings of sleep, the effect of hypoxia, a variety of diffuse and localized brain disorders, and epileptic discharges. Afterwards, Edgar Douglas Adrian (1889-1977) continued and confirmed Berger's work, being one of the greatest electrophysiological neurophysiologists. Fisher and Lowenback demonstrated epileptiform spikes, in 1934, and Gibbs, Davis and Lennox started the field of clinical electroencephalography, in 1935. During this period EEG found great effectiveness in domains like human epileptology, human sleep and clinical EEG research. Then W. Grey Walter discovered the delta waves. In 1951, George D. Dawson demonstrated evoked potentials to electrical stimulation, becoming the father of evoked potentials studies. In the 60's EEG work reached its peak, as the attention of the researchers shifted from tracing to automatic data analysis. In the 1970's and 1980's new neuroimaging techniques emerged (computed tomography (CT) and magnetic resonance imaging) that seemed would put an end to the use of EEG in clinical practice. However, though clinical EEG has been declining, except for epileptology, new developments on EEG like computerized brain mapping still makes EEG an attractive, and less expensive technique than others (Niedermeyer and Lopes da Silva 2005). Additionally, EEG is also the most common technique used in sleep studies (Campbell 2009). Combining EEG, EMG and electrooculogram (EOG) provides an essential method in sleep research – polysomnography (Šušmáková 2004).

1.2.3 Neurophysiological basis of EEG

EEG is a central nervous system measurement that records the electrical activity of the brain. So first we shall mention basic notions about the brain and the nervous system. The nervous system contains a network of specialized cells, the neurons that coordinate actions and transmit signals between different parts of the body. It can be divided into two parts: central nervous system and peripheral

nervous system (PNS). The CNS includes the brain, the spinal cord and the retina, whereas the PNS consists of sensory neurons, ganglia, and nerves that connect to each other and to the CNS. The CNS is protected by a three-layered system of membranes called meninges, and in the case of the brain also protected by the skull. We can also divide the human nervous system into two areas: grey matter, and white matter. The grey matter has high density of cell bodies of the neurons, while white matter contains mainly myelinated axons. Grey matter is found in clusters of neurons in the brain and spinal cord (nucleus) and in cortical layers, whereas white matter appears in peripheral nerves and much of the interior of the brain and spinal cord. Scientists by the end of the eighteenth century had dissected all the nervous system, and had observed that the brain had some interesting anatomical patterns, that allowed dividing the cerebrum into lobes. They speculated that different bumps of the brain had different functions. The era of cerebral localization was born (Bear, Connors et al. 2007). The brain can be divided into six main areas (see Figure 1): the telencephalon (cerebral hemispheres), diencephalon (thalamus and hypothalamus), mesencephalon (midbrain), cerebellum, pons, and medulla oblongata (Kandel, Schwartz et al. 2000). The telencephalon can be divided into four lobes (cortical division): frontal lobe (responsible for conscious thought), parietal lobe (responsible for integrating sensory information, manipulation of objects, and some parts are involved in visuospatial processing), occipital lobe (responsible for the sense of sight), and temporal lobe (responsible for the sense of smell and sound, and the processing of complex stimuli) (see Figure 2). The hypothalamus is a small region at the forebrain, responsible for the control of sleep and wake cycles, eating and drinking, hormone release, and many other important biological functions. The thalamus, like the hypothalamus, is a small region formed by nuclei with different functions like: communicating information to cerebral hemispheres; motivation; action-generator systems for behaviours such as drinking, eating, and copulation. The cerebellum adjusts outputs of other brain regions to make them more precise; without it actions would be more clumsy and hesitant, and it is responsible for the body's balance, posture and coordination of movements, and it is involved in emotion and cognitive function (Aftanas and Pavlov 2005). It is also important to refer other functions of structures and regions that are essential in this study. The upper frontal lobes are associated with cognitive behaviour and action planning, whereas lower parts, the limbic association cortex, are responsible for emotion and memory. The cingulate gyrus and the region around the hippocampus are also responsible for those functions. Evidence suggests that regions close to the anterior and posterior end of the cingulate are important for emotional processing and fundamental for whether a stimulus is memorized or not. Also, the cingulate cortex has many subdivisions responsible for cognitive, emotional, motor, nociceptive and visuospatial functions (Bush, Luu et al. 2000). The septal area and the amygdala are involved in emotional processing and the hippocampus is involved in memory, together they are responsible for initial memorization and processing emotional experiences, creating pathways to long-term memory (Ambler, Ioannides et al. 2000).

The human brain can also be divided according to its functions. There are three functional categories of areas: primary sensory areas, primary motor area, and association areas. Apart from this division it is known that the cerebral cortex is involved in many cognitive and behavioural functions, so anatomists have been creating maps of cortical areas on the basis of variations in layers as viewed on

the microscope. The most used was defined by Korbinian Brodmann, dividing the brain into 51 different areas giving to each area one number (see Figure 3). In the beginning, the division was only based on neuronal organization but since its creation it has been correlated to cortical functions (the full list of Brodmann areas (BA) can be seen in (Lloyd)).

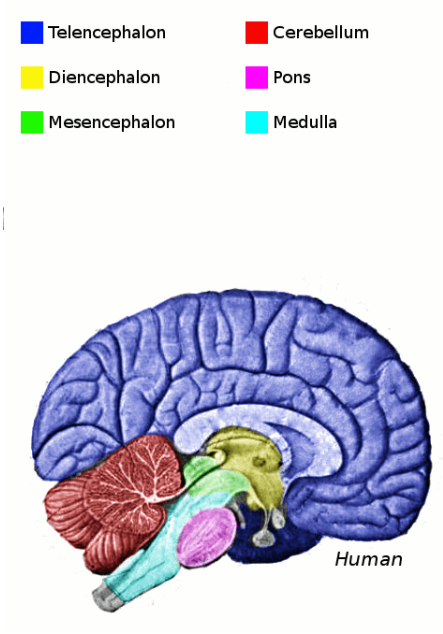

Figure 1 Main regions of the human brain.[1]

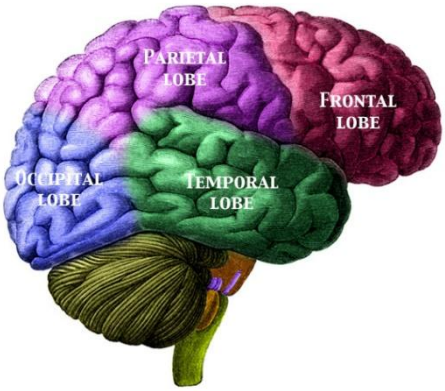

Figure 2 Brain viewed from the right side showing the 4 major cerebral lobes.[2]

[1] Adapted from Ranson, S. (1920). Main regions of the vertebrate brain., WB Saunders.

[2] Retrieved from Morel, C. and M. Duval (1883). Brain viewed from the right side showing the 4 major cerebral lobes, Manuel de L'anatomiste.

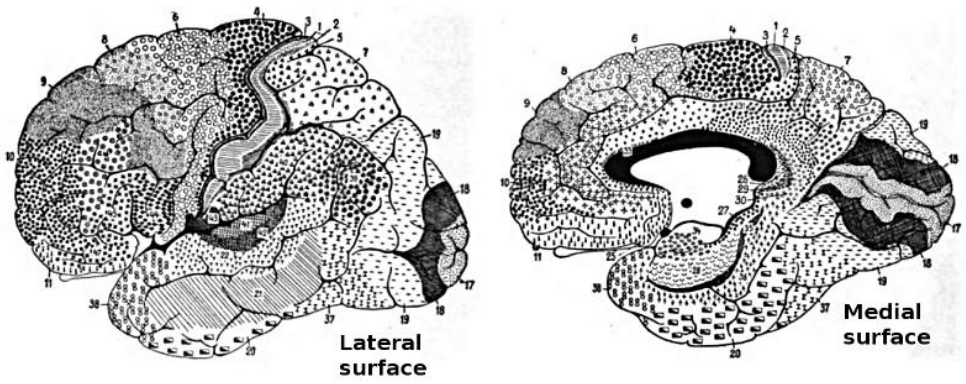

Figure 3 Representation of the regions of the human cerebral cortex as delineated by Korvinian Brodmann on the basis of cytoarchitecture.[3]

The human brain is constituted by two main broad categories of cells: neuron and glia (see Figure 4). It has been estimated to have 50-100 billion neurons, 10 billion being cortical pyramidal cells, and a number one order higher of glial cells. Despite the higher number of glial cells, it is thought that their main brain function is insulating, supporting, and nourishing neurons, while neurons are the most important for exceptional brain functions (Bear, Connors et al. 2007). So we will focus our attention on neurons. Neurons can be classified in different ways, according to their function, location, depending on the transmitter they synthesize and release, shape, axon length, and the number of neuritis (any projection from the neuron, e.g. axon or dendrite) (Squire, Bloom et al. 2003; Bear, Connors et al. 2007). Almost all neurons have one axon that transmits signals to interconnected neurons. Axons begin in the region axon hillock, and can extend from millimeters to meters, ending on an axon terminal. The terminal is where the contact with the other neuron is made, passing the information. The point of contact is called synapse. The processes that extend form the nerve cell body to receive the synaptic contacts are called dendrites that work as antennae of the neuron.

[3] Adapted from Brodmann, K. (1920). This drawing shows the regions of the human cerebral cortex as delineated by Korvinian Brodmann on the basis of cytoarchitecture., W. B. Saunders.

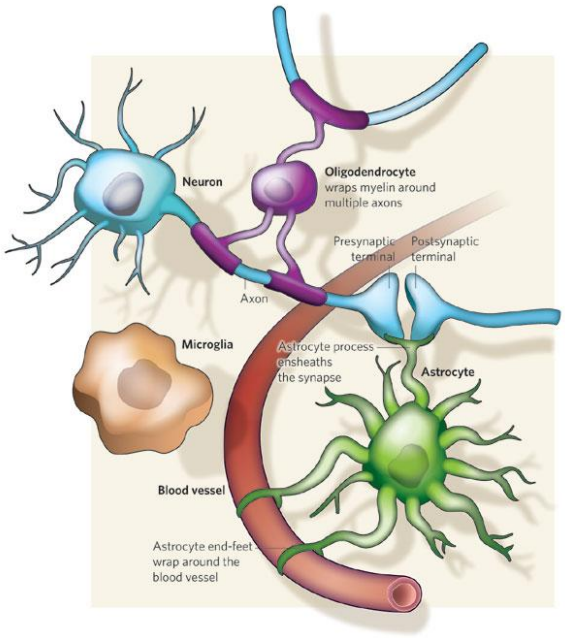

Figure 4 Glia interacting with neuron and the surrounding blood vessels.[4]

We shall now give a brief description of the basic mechanism of the creation of potentials recorded by the EEG. First the neurons create the electric signals that travel down the axons (action potentials) causing the release of chemical neurotransmitters at the synapse. These neurotransmitters activate the receptor in the dendrite or body of the other neuron called post-synaptic neuron. The binding of the neurotransmitter with the receptor causes an electric current that summed up with all the post-synaptic currents from a single neuron's dendrite generates an action potential. This process will go on from neuron to neuron. What EEG reflects is the correlated synaptic activity caused by post-synaptic potential of cortical neurons. Because electric potentials created by a single neuron are very small to be captured by the EEG, its activity is the summation of synchronous activity of thousands or millions of neurons that have a similar spatial orientation and that are more at the cortex, since voltage field decreases with the square of the distance (Nunez and Srinivasan 2006).

We will now mention one of the most important assets used in EEG studies and clinics: brain waves. Rhythmic electrical activity in the brain was the first evidence that linked electrophysiological processes with behaviour (Feige, Scheffler et al. 2005). It is generally accepted that they are produced by means of cartels (inhibitory and excitatory population of neurons) (Van Rotterdam, Lopes da Silva et al. 1982). While doubts still exist about the functional role of this synchronized synaptic activity some have hypothesised that it involves different brain structures ("binding phenomena") (Moosmann, Ritter et al. 2003). Recent studies have been focusing on discovering what structures of the brain are responsible for some rhythms, combining techniques like EEG and fMRI, which enables the spatial resolution lacking if we just used EEG. The first one to be discovered, as mentioned earlier, was the alpha activity (8 to 13 Hz), others frequencies are: delta (1 to 4 Hz), theta (4 to under 8 Hz), beta (14 to 30 Hz) and gamma (30 to 70 Hz).

[4] Retrieved from Allen, N. J. and B. A. Barres (2009). Glia–neuron interactions.

1.2.4 State of the art of EEG

EEG has already a big history, but recently new improvements and new technologies have given EEG a new strength. In this section will be described the new developments in equipment, models and techniques, like the high-resolution EEG.

The electrical brain activity captured by the EEG has less than 100 μV making it difficult to have completely clean signals. The first EEG equipments to be considered are the electrodes. The electrodes are used to capture the signal and in EEG are usually made of metal and can be cup-shaped, disc, needle, or microelectrodes for intracranial EEG. For common applications silver chloride (AgCl) is the most used material for the electrodes. Also, the EEG electrodes can be polarized or non-polarized. Polarized ones are avoided since the chloride ion is common to the electrode and the electrolyte, and they tend to make higher capacitance. Other metals like gold and platinum could be used but are more expensive. Non-polarized electrodes are more used for neurophysiological applications. EEG electrodes can also be disposable, reusable disc and cup shaped (EEG caps), sub-dermal needles, and implanted electrodes. The ones used in our experiment are an EEG cap and disc electrodes for the vertical and horizontal electro-oculograms. When using a non-invasive electrode there is an interface material between electrode and skin for better capture of the signal. The material used is an electrolyte as an EEG gel or paste. The 10/20 electrode placement system[5] is the standard and general placement in EEG recordings for most of the clinical and research experiments (Klem, Lüders et al. 1999). With this system there are 75 locations, though for clinical purposes 8 to 32 electrodes are enough. However, in our case because we want to perform a brain imaging analysis, we used 64 electrodes. Currently there are caps with 256 channels, but up to 354 electrode locations can be used with the 10/5 electrode system. The more electrodes we have the more precisely we can use brain imaging methods in EEG, but the more time is needed for the preparation of the participant and there is more risk of having conduction bridges between electrodes through the EEG gel. To decrease the preparation time several approaches have been developed, such as: multi-array thin film electrodes, nitride-covered steel electrodes, active electrode, and dry electrodes (Usakli 2009).

As described, the great advantage of EEG is its temporal resolution, but investigators now have been trying to improve the spatial resolution, by increasing the number of electrodes, and by developing algorithms that restore lost high-frequency components. This approach is called High-Resolution EEG. Because signals measured in the scalp do not give the location of the activated neurons due to ambiguity in the static electromagnetic inverse problem, researchers have to try to solve this by using dipole models or spatial enhancement approaches like current source density calculations or deblurring (He, Wang et al. 1999; Michel, Murray et al. 2004). The approximate solution of the inverse problem is achieved by introducing assumptions on the generation of EEG signals, and the better these assumptions are the better the sources estimations.

Now we will introduce a brief review of some of the methods that investigators have been coming up with. First off, there are the dipolar models, which are based on the assumption that a small number of

[5] Klem, Luders et al. (1999) first defined the 10/20 system. The 10 and 20 refer to the 10% and 20% (of the total size of the head, measured from nasion to inion) inter-electrode distance at which they are placed.

current sources can be adequately modelled by the surface measurements. To localize the sources is computed the surface electric potential map generated by the dipoles and compared with the actual measured potential map. The basic comparison is the least-square method, where the optimal solution is when the square error between the two maps is minimal. The two main limitations of dipole source localization methods are that they can find a local minima and not the absolute one, and that the complexity of these algorithms increases with the number of dipoles. Investigators have been coming up with some approaches, and one of them is using data from PET or fMRI to define the number of dipoles (He and Ding 2004; Michel, Murray et al. 2004).

In underdetermined source models no prior assumptions on the number of dipoles are made, thus it is needed to reconstruct the brain electricity in each point of a 3D grid. Because of the undetermined nature of these source models, it is necessary to apply other assumptions, some only mathematical, others biophysical or physiological. One of the approaches is Laplacian weighted minimum norm. This model is an improvement of the weighted minimum norm that selects the solution with a smooth spatial distribution by minimizing the Laplacian of the weighted sources (Michel, Murray et al. 2004). In our study we use the Low Resolution Electromagnetic Tomography (LORETA) method computed in Talairach space[6] available for free. There are other undetermined source models like Local Autoregressive Average (LAURA), EPIFOCUS, Bayesian approaches, and so on. What is important to retain is that more and more investigators try to incorporate anatomic details into EEG to improve its spatial resolution.

Pascual-Marqui, Michel et al. (1994) proposed an approach to find a direct 3D solution of the electrical activity distribution that could be called a “tomography” as techniques like PET, fMRI or CT. They had to sacrifice spatial resolution by creating a 3D grid where for each grid point the electrical sources are located. The crucial issue is to find a meaningful solution among the infinite different solution. They had to make assumptions. The physiological consideration made is based on the statement that neighbouring neurons are most likely to be active synchronously and simultaneously, thus neighbouring grid points are more likely to be synchronized (similar orientation and strength) than the ones far from each other. Mathematically the solution is found by maximization of the smoothness. This solution produces a “blurred-localized” solution hence the name Low Resolution Electromagnetic Tomography.

In our study we used an improved version the sLORETA that stands for standardized low resolution electromagnetic tomography. This method has a lower localization error (Pascual-Marqui 2002). The reasons why we chose this method are:

- comparing with dipole fitting, LORETA is more suitable to use when brain activity is not confined to single point sources (Pascual-Marqui, Esslen et al. 2002);

[6] Talairach space it is defined by x, y, and z coordinates, being x the left versus right, y the anterior (rostral) versus posterior (caudal), and z the superior (dorsal) versus the inferior (ventral). This coordinates provide a standardize method of localization brain structures (Amodia and Frith 2006).

- studies have proved that from methods like minimum norm, weighted minimum norm, Backus and Gilbert, weighted resolution optimization (WRO), it is LORETA that has the lowest localization error and it is capable of correct localization in 3D space (Pascual-Marqui 1999; Pascual-Marqui, Esslen et al. 2002).

1.3 Review of studies on neuromarketing

In this chapter neuromarketing studies and their conclusions will be briefly addressed. The applicability of some conclusions and methods will also be discussed here. We tried to select the most important studies, with special focus on works developed in marketing research with TV commercials.

Advertising research is one of the many fields of marketing research, and where neuroscience has been helping out. The goal of advertising research is to improve the efficiency of advertising, whereas the goals of advertising are to influence: consumer's decision; response to products; and consumer's experiences (Kenning, Marci et al. 2008). In this particular study we wanted to know how the brain works during the visualization of TV commercials, which can be considered a sub-area of neuromarketing, consumer neuroscience. TV and cinema are the most expensive medium of advertising. Major brands use it because of their ability to reach a broader population, and at the same time create strong brand images (Burtenshaw, Mahon et al. 2006) and because they have the necessary financial funds. Because of its high cost, advertisers have been trying to improve their commercials, and to understand how ads work. Two main "*visions*" exist: ads work rationally; and effective ads trigger emotion. Recent studies confirm that emotional responses are essential to the effectiveness of an ad, and are essential in consumer decision-making (Ambler, Ioannides et al. 2000).

The use of EEG and other techniques on the study of the reaction to TV advertising has already been addressed, from the study of asymmetries on the brain (Davidson and Hugdahl 1996; Ohme, Reykowska et al. 2010), to the study of long-term memory and development of new methods like steady-state visually evoked potential (SSVEP) (Silberstein, Harris et al. 2000; Rossiter, Silberstein et al. 2001), attention, emotional processes, and functional brain mapping (Wang and Minor 2008). More importantly some theories have been created, that will support us through this thesis.

In 1999, Ambler and Burne created the Memory-Affect-Cognition (MAC) theory. Cognition, which is the "thinking" dimension, Affect, which is the "feeling" dimension or the emotional response, and Memory are responsible for the common decisions of a person. What these researchers have been trying to prove is that most of our daily decisions require only our memory, and the rest require memory and affect. Conversely, cognition is only required for rationalization after a decision is made and in some cases where the three are all used (Ambler and Burne 1999). Some findings suggest that the memorization and the affective dimensions of content in a commercial are correlated, but how that affects brand perception is still unclear. We will take in consideration these findings in our thesis. Until recently advertising research has been dominated by "hierarchy of effects" models, where the processing of advertisements followed a series of stages with emotional engagement following cognitive engagement: Cognition – Affect – Behaviour (Vakratsas and Ambler 1999; Ambler,

Ioannides et al. 2000). Each stage is a gate, and according to this model if an ad did not engage rational process then no affective processing would occur too.

Another area where neuromarketing is interested in and neuroscience has been helping is on finding where in the brain emotion is being processed. The theory existing until recently was that emotion and rationality were represented in different regions of the brain (Rossiter, Silberstein et al. 2001), but now results show that the ventromedial prefrontal cortex (VMPFC) and the striatum are important in bilateral emotion processing (Ochsner and Gross 2005). Attractiveness of an advertisement has been correlated with variations in brain activity in regions like the medial prefrontal cortex, posterior cingulate, nucleus accumbens and high-order visual cortices (Plassmann, Ambler et al. 2007). Other results have shown: that commercials where people portray positive emotions are perceived, generally, as more attractive than the ones exclusively with written text and showing people with neutral expressions (Plassmann, Ambler et al. 2007); unattractive advertisements activate the anterior insula (Greene, Sommerville et al. 2001); and attractive and unattractive ads are more memorable than ambiguous ones (Plassmann, Ambler et al. 2007). Again more research in this field is necessary when it comes to how this affects brand perception. Thus, we intend with this thesis not only to reproduce some part of these experiments, even though using a technique that has worse spatial resolution, but to aim for some conclusions about brand perception.

It has been demonstrated that TV commercials with more than 1.5 seconds are more memorable, and that scenes producing quickest electrical response in the left frontal hemisphere are also more memorable too. Rossiter, Silbertsein et al. (2001) believe that the transfer of visual input from short term memory to long-term memory takes place in the left hemisphere, and that is why memorable ads produce fast responses in the left hemisphere. That study had some controversy concerning its experimental design, and it was pointed out that extraneous factors were not considered (Crites and Aikman-Eckennrode 2001). It has also been suggested that for memorization, more important than left to right hemisphere differences is front to back difference in speed processing (Kemp, Gray et al. 2002). We intend with this thesis also to study these asymmetries between right and left hemisphere.

Frequency bands have been studied in identifying the “branding moments” (Young 2002). These moments are some of the most engaging parts of a commercial, and it is thought that the strength of these moments can permit inferences about the effect that a commercial can have on a consumer. Young hypothesized that within some TV commercials there are “branding moments”, and these moments can create a connection between brand imaging and product positioning, which can be critical to understand the long term contribution of an ad to a brand’s equity. Because we use EEG in our study, frequency bands analysis is a major step and probably one of the most straight-forward we could perform, and we do expect to get similar results.

Some researchers have been turning, for some time, their attention to brand equity. Brand is now considered to be of the utmost importance in companies (Neumeier 2006). Brand equity is the effect or outcome that a brand adds to a product. Researchers in neuromarketing are interested in answering questions like: how can brands create value to a product; what happens in the brain when

viewing an ad, and how does that affects brand perception. We too wonder what knowledge can we extract from asymmetries and apply in brand equity studies. The final and general question is what we know about brand perception and what can we know more.

Many studies research what is called brand memories, which can be defined as all the qualities a brand can have on the consumers' mind, such as thoughts, feelings, experiences, images, attitudes (Keller and Lehmann 2003). Other studies show that there is no specific brain region responsible for brand recognition (Kenning and Plassmann 2008). More controversial is whether brands are or not perceived by the brain with person qualities. Some studies concluded that the evaluation of a brand in the brain is processed in a different region than when it is a person and in fact the activated areas were the same as the ones responsible for semantic object processing (Yoon, Gutchess et al. 2006). That study was the object of some criticism, mainly because they only used the names of the brands and not the logos, and some can claim that a bias towards semantic object processing was made from the beginning. Also brands are considered by some more than just the logos, the colours or the slogans, being for example cultural elements, and can override sensorial information (Schaefer, Berens et al. 2006; Koeneke, Pedroni et al. 2008).

It is important to understand what brand is. We can define brand as the identity of a product, service, or business that helps to connect the consumer to the product, service, or business, by establishing an emotional connection or image. Neumeier (2006) defines brand as the "gut feeling" that people have about a product. About how a brand can affect the consumers one particular and well-known study is worth mentioning. The study opposes two culturally familiar drinks, Coca-Cola® and Pepsi® (McClure, Li et al. 2004). The starting point of this study was why people reacted so extremely to these two drinks when they have a nearly identical chemical composition, and how cultural messages interfere with our perceptions at the point of changing behavioural preferences. They delivered the two drinks in behavioural taste tests and while using functional magnetic resonance (fMRI), in two conditions: brand-cued and anonymously. McClure and collaborators concluded that, when judgements were based on sensory information, the VMPFC was more activated and predicted subject's preferences; however when it was brand-cued, especially for Coke, the hippocampus, dorsolateral prefrontal cortex (DLPFC), and midbrain were recruited, suggesting that brand-knowledge biases the preference. This study was major in consumer neuroscience as it demonstrated that cultural information can interfere, and overcome, judgements based on sensory information (Kenning, Plassmann et al. 2007).

At last, it is of the utmost importance two refer two models that will be useful for the interpretation of the results: Davidson's model and Hemispheric Encoding/Retrieval Asymmetry (HERA) model.

HERA model is described by five statements (Tulving, Kapur et al. 1994):

- Left and right prefrontal cortex are differently involved in episodic and semantic memory process;
- Left prefrontal cortex is involved in retrieval of information from semantic memory, at least for verbal information;

- Left prefrontal cortex is involved in encoding information about new happenings into episodic memory, at least for verbal information;
- Right prefrontal cortex is involved in retrieval of episodic information;
- Right prefrontal cortex is involved in retrieval of episodic information not only of semantic information.

Conversely, Davidson's model claims that prefrontal cortical regions are involved in approach-related behaviour and positive affect and the right prefrontal cortical regions in withdrawal-related behaviour and negative affect (Davidson, Ekman et al. 1990).

Additionally, it is represented in the Table I studies in consumer neuroscience. The table contains information about the objectives or problem to be addressed (Aims), neuroscience technique used (Methods), the Experimental set-up, the number of subjects (*N*), and the main Results.

Table I Overview of studies in consumer research in alphabetical order

Study	Aims	Method	Experimental set-up	*N*	Results
Ambler and Burne, 1999	Four hypotheses were tested. • H1: Ads with higher affective content have higher recall. • H2: Ads with higher affective content have higher recognition. • H3: Subjects given β-blockers have lower recall than the ones given placebo. • H4: Subjects given β-blockers have lower recognition than the ones given placebo.	No neuroscience technique was used	The experiment had a two by two design (low vs. high affect ads and placebo vs. β-blockers). The subjects watched two blocks of four ads, and answer questionnaires one day after and 3 to 4 weeks later	*n* = 20	Hypotheses [H1], [H2] and [H3] were confirmed. However, the significance for [H4] was not definitive

Table I Overview of studies in consumer research in alphabetical order (Continued)

Study	Aims	Method	Experimental set-up	*N*	Results
Ambler, Ioannide *et al*., 2000	How advertising works?	MEG	Two small-scale experiments. One testing how emotional ads are more easily remembered. In the second, subjects watched different commercials while doing MEG measures	*n* = 3	Cognitive pictures had stronger activation in posterior parietal regions and in the superior prefrontal cortex. Affective pictures had stronger activity in areas like VMPFC, the amygdala and the brainstem
Astolfi, Fallani et al., 2008	What brain regions are more activated when watching TV commercials that are remembered?	EEG	Subjects watched for five consecutive days a documentary with three interruptions with six ads each, while recording the EEG. An interview occurred ten days after	*n* = 10	Remembered commercials activated posterior parietal cortices and prefrontal areas
Deppe, Schwindt et al., 2005	How individual economic decisions are influenced by implicit memory of a brand?	fMRI	Participants had to make binary decisions between different brands of a type of consumer goods	*n* = 22	The favourite brand lead to a reduced activity DLPFC, posterior parietal, and occipital cortices and the left premotor area (analytical processes), and lead to an increase activation in the inferior precuneus and posterior cingulate, right superior frontal gyrus, right supramarginal gyrus and VMPFC

Table I Overview of studies in consumer research in alphabetical order (Continued)

Study	Aims	Method	Experimental set-up	*N*	Results
Fugate, 2007	Cover the origins of neuromarketing and suggest future consumer behaviour research	No neuroscience technique was used	The methodology used was based on reports of theoretical and applied nature	*n* = 0	Traditional assumptions about consumer behaviour and approaches used might be less powerful than believed
Greene, Sommerville et al., 2001	Exploration of emotion's role in moral judgement	fMRI	Subjects responded to 60 dilemmas divided into three groups moral-personal, moral-impersonal and non-moral, while undergoing fMRI	*n* = 9	Results revealed that medial frontal gyrus, posterior cingulate gyrus and angular gyrus were more activated during moral-personal conditions (areas associated with emotion), whereas right middle frontal gyrus and parietal lobe (areas associated with working memory) were significantly less active
Heath, 2009	Proposal of a new definition of engagement and development of a model that shows how strong brands can be built	Eye movement	It was fitted on the subjects a lightweight head-mounted eye camera. Subjects had to read a newspaper and then watch a sitcom interrupted three times with TV commercials	*n* = 17	Print advertisement had greater levels of attention when comparing to TV advertisement. However, TV advertising is a high engagement medium

Table I Overview of studies in consumer research in alphabetical order (Continued)

Study	Aims	Method	Experimental set-up	*N*	Results
Kemp, Gray et al., 2002	Examine the steady-state visually evoked potentials associated with the processing of pleasant and unpleasant images	Steady-State Probe Topography	Subjects were presented with 75 images divided into three groups: pleasant, unpleasant and neutral	*n* = 20	Pleasant and unpleasant valence is associated with transient, widespread, and bilateral frontal SSVEP latency reductions. Unpleasant is also associated with a transient bilateral anterior frontal amplitude decrease
Kenning, Plassmann et al. 2007	What brain regions highly liked ads activate?	fMRI	The subjects rated 30 ads as liked or non-liked, which had previous been separated into: highly liking, neutral and low liking.	Pre-study: *n* = 100 Main study: *n* = 22	The nucleus accumbens, posterior cingulate, medial prefrontal cortex, and higher order visual cortices are more activated when watching highly liked ads. Strongest differences were found for the nucleus accumbens and the fusiform face area
Koeneke, Pedroni et al., 2008	The hypothesis to study is if individual brand preferences modulate activity in reward regions	fMRI	Subjects played a wheel-of-fortune presented by a video projector while inside a MRI scanner. They played for chocolate bars of three brands	*n* = 19	In the anticipation phase the responses in the premotor cortex, the insula, and the dopaminergic midbrain are linearly correlated with the subjective preference of a desired brand. Whereas, left middle frontal gyrus, posterior cingulate cortex are negatively correlated with the expectation of winning the brand

Table I Overview of studies in consumer research in alphabetical order (Continued)

Study	Aims	Method	Experimental set-up	*N*	Results
Krugman, 1971	Is it television a medium of low involvement as compared with print?	EEG	The participant was given magazines to read while recording the EEG, and then saw three TV commercials	*n* = 1	Response to print advertisement is composed by primarily of fast brain waves and response to TV advertisement of slow brain waves
McClure, Li et al., 2004	How cultural messages can shape our perceptions to the point of modifying behavioural preferences?	fMRI	Behavioural taste tests with anonymous and brand-cued delivery of Coca Cola and Pepsi	*n* = 67	In the anonymous task, the VMPFC was activated corresponding to sensory information. In brand-cued delivery, the DLPFC and the hippocampus were activated, because of memory and cultural information
Ohme, Reykowska et al., (2010)	Identify frontal cortex activation in reaction to ads	EEG	The subjects watched saw 3 ads of a specific target brand and 30 other brands	*n* = 45	Approach reactions to an ad generates greater relative left frontal activation (measured in the alpha band)
Rossiter, Silberstein et al., 2001	Neural correlates of ads recall	Steady-State Probe Topography	In session 1, participants watched a documentary interrupted 12 commercials while recording EEG. In session 2 they did a recognition memory test	*n* = 35	Faster brain electrical activity response only in the left hemisphere is evident in remembered ads, supporting hemispheric encoding/retrieval asymmetry (HERA) model

Table I Overview of studies in consumer research in alphabetical order (Continued)

Study	Aims	Method	Experimental set-up	*N*	Results
Schaefer, Berens et al., 2006	Neural correlates of brand knowledge	fMRI	The subjects were presented with logos of car brands (some cultural familiar and others cultural unfamiliar) and asked to imagine themselves driving	*n* = 13	Activation of the medial prefrontal cortex when exposed to familiar brands
Yoon, Gutchess et al., 2006	Investigation of whether semantic judgements about products and people are processed similarly	fMRI	Participants had to make judgements about whether a trait adjective would describe a target cue that could be either a product or a person	Pre-study*:* *n* = 152 Main study: *n* = 25	When characterizing person attributes stronger activation of the medial prefrontal cortex was recorded in comparison to brand characterization. Stronger object related brain areas activation was measured for products' evaluation
Young, 2002	Description of a method to identify potential branding moments	EEG	In the first study, subjects were interviewed about eight TV commercials. In the second study, other subjects watched the same eight ads while recording their electrical brain signals	Picture-Sorting*:* *n* = 125 Brain waves: *n* = 100	By intersecting the two methods they found out that they uncorrelated. Branding moments was defined as an essential moment for the long-term memory and branding building effects

1.4 Motivation and Objectives

During the experiment built for this study, we intend to test briefly explore the following areas:

– confirm if the EEG is a reasonable valid and reliable technique on the localization of activated brain's structures during the visualization of short commercial movies;

– identify the key moments of a TV commercial;

– understand how brand perception influences when watching ads of the brand;

– differences between ads that have different scores (better score vs. worse score).

As it was said previously, neuromarketing is still a young field and in a growing stage, much more research is needed. General theories are yet to be created, validation is yet needed for some psychophysiological techniques, for how brands are perceived in the brain, and what mechanisms are really involved is still unknown. It is on these areas that we propose our work, hoping to create helpful guidelines for future researches. This work intends to add knowledge by using EEG and the three CNS measures (non hemispheric brain wave analysis, brain lateralization, and brain imaging analysis), and we aim to validate not only EEG as able to make the three CNS measures but validate the use of EEG in marketing research, specifically in advertising.

For these reasons we selected 30 TV commercials that with a specific experimental setting were presented to 20 participants. Recording of EEG was constant during all ads, and afterwards by selecting specific videos we perform the three measures hoping to find answers and conclusions supporting our goals. It is important to remember that this thesis is exploratory since using EEG for brain imaging analysis is very recent.

2. Experimental Design

2.1 Participants

We selected 20 male participants aged from 20 to 28 years (mean age = 23.05 ± 1.045), all right-handed, and mainly students from the university. We chose only right-handed individuals because of differences that occur in brain lateralization between right- and left-handed. With these constraints we obtained a homogenous group in terms of gender, age and laterality, which is important in experiments like this.

2.2 Procedure

In the beginning of the experimental design of this study we followed some guidelines given by Harmon-Jones and Beer (2009). Because the experiment could be long, and participants might not be familiar with the technology used, they could feel uncomfortable. So we adopted a friendly and familiar conversation with them, avoiding the use of words like needle, electricity, and so on. Before starting the preparation of the participant we gave them the Informed Consent (in Appendix A), which they signed, and enlightened them on what would happen during the experiment. After informing the participant about what was going to happen we started the preparation time. During this preparation time, we cleaned the face of the participant with an exfoliant (Nuprep™), in the forehead, in the earlobes, and the places where the vertical electro-oculogram (VEOG) and horizontal electro-oculogram (HEOG) electrodes would go. These electrodes are made of tin (Sn) or silver/silver chloride. This procedure is essential for the removal of dead skin and the decrease of the impedance of the skin on those places. Afterwards we used alcohol to remove the excess exfoliant.

The electrode placement system we used was a 10-10 system. That is an expansion of the 10-20 system, where the first frontal electrodes are placed 10% of the total length (measured from the nasion to the inion) above the nasion, and the rest of the electrodes are spaced 10% between them (see Figure 5). The cap we used had 64 channels and its size was Medium (54 to 58 cm of head circumference). It is also important to mention the reference used. We opted to use a common average reference, although we placed electrodes on the earlobes, because we were going to analyze the data with LORETA and this method recalculates the data to a common average reference (Murray, Brunet et al. 2008). After the placement of the cap we would fix it with a band around the participant's chest.

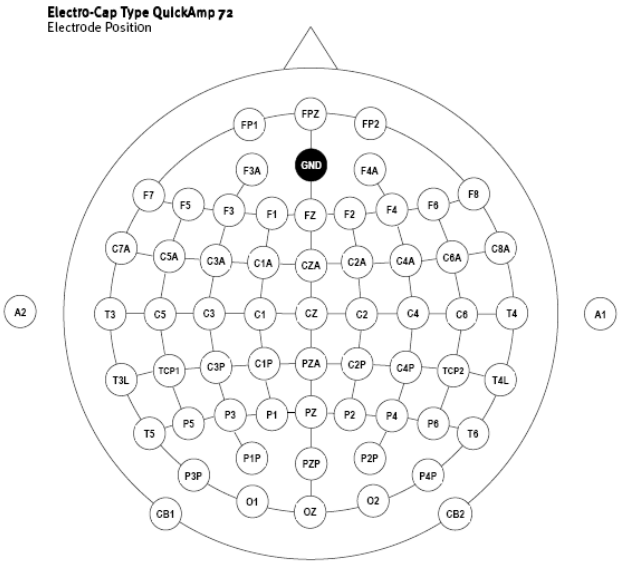

Figure 5 Electrode placement system (10/10) used in this work. The taxonomy is different than the generally used (F3A=AF3; F4A=AF4; C7A=FT7; C5A=FC5; C3A=FC3; C1A=FC1; CzA=FCz; C2A=FC2; C4A=FC4; C6A=FC6; C8A=FT8; T3L=TP7; TCP1=CP5; C3P=CP3; C1P=CP1; PzA=CPz; C2P=CP2; C4P=CP4; TCP2=CP6; T4L=CP8; T5=P7; T6=P8; CB1=PO9; P3P=PO7; P1P=PO3; PzP=POz; P2P=PO4; P4P=PO8; CB2=PO10).

Because the electrical activity of the brain is so low (10 µV to 100 µV) we need to have very low impedance on the electrodes of the cap. The recommendation in the literature (Harmon-Jones and Peterson 2009) is that impedance must be kept lower than 5 kΩ, and to do so we filled the sensors with gel (ELECTRO-GEL™). This step was critical in the preparation time, as it consumed most of the time, and as it could turn out to be uncomfortable for the participant. One of the reasons was that to fill the electrodes with gel we had to use a needle, without a sharp end, but that still could be scratchy. To make this step more bearable we would talk with the participant, and let him play on the computer where the stimuli would be presented, so they could be distracted.

During this step, the cap was already connected to the amplifier that was connected to the computer where the recording of the EEG and the analyzing process of the results would happen (the computer of the presentation of the stimuli and the computer for the analysis are not the same). It was through this computer and the software (BrainVision 2.0), which came with the amplifier and all the hardware needed for the EEG (Brain Products), that we checked the impedances in each channel of the cap.

Finished with the electrolyte filling, we presented the stimuli. It was necessary to use the software E-Prime 2.0 to make the presentation and synchronization of the stimuli with the EEG. During the presentation of the TV commercials, the subjects were isolated from anything that could distract them, and seated 1 meter apart from the computer screen. The computer screen had 19 inches and a screen refresh rate of 74 Hz. It is important to notice that the refresh rate of the monitor is higher than the frame rate of the videos (18 frames per second), so no frames were lost during the presentation of the videos. The chair had to be comfortable as the total time of the stimuli presentation was around 20 minutes, and during that time it was asked for the participant not to move much to reduce muscle and eye movement artefacts. It is also important to mention the sampling frequency used for the EEG record was 500 Hz. After the presentation we would take off the electrode cap, and the participant

washed his head. Then the participant was asked to answer a questionnaire, again in the computer. The questionnaire consisted of closed answers, with a Likert scale. The questions were about the brands they saw in the TV commercials and whether they liked it or not (1 – hate it, 2 – didn't like, 3 – indifferent, 4 – like it, 5 – love it). We also did another questionnaire about the TV commercials, again with a Likert scale (1 – hate it, 2 – didn't like, 3 – indifferent, 4 – like it, 5 – love it), but because it was sent to be answered later we did not received all the answers (16 out of 20).

Overall, the equipment used for this part of the experimental design was: an electrode cap with 64 channels, a computer with the software needed to record and analyze the EEG, an amplifier, another computer where the visual stimuli would be presented, the gel for the impedance, the exfoliant, alcohol, and a comfortable chair for the participant. Figure 6 shows where the experiment took place, and you can see the computer and the cap.

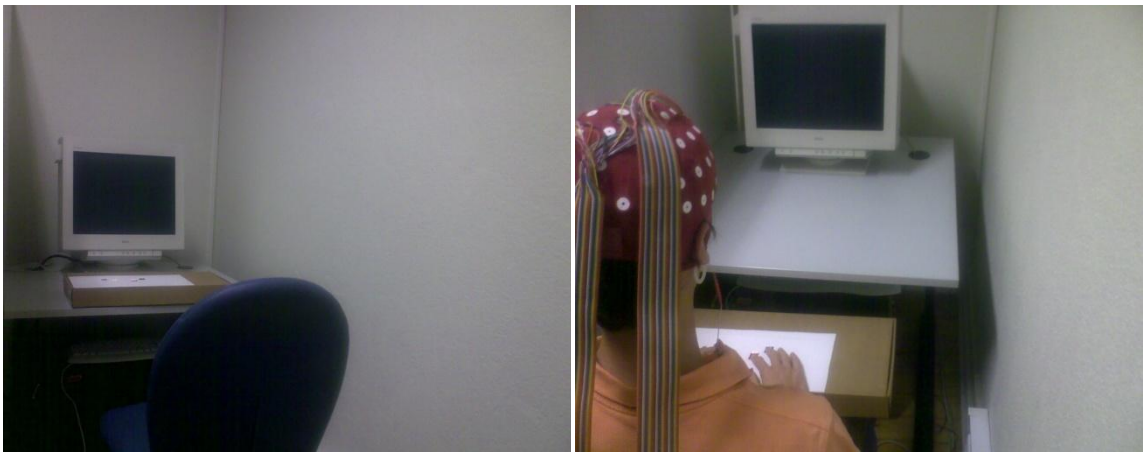

Figure 6 At the left you can see the monitor, where the experiment was presented, the keyboard used and the chair. At the right you can see the cap used, and a representation of how the participant would see the stimuli.

2.3 The paradigm

The paradigm of the experiment consists of five blocks of six different TV commercials each one. The TV commercials have approximately 30 seconds each. Between each video there is an inter-stimulus of 6 seconds duration. This inter-stimulus is a black cross. The order of appearance of each block is random. Each block has six TV commercials as represented in Table II. In total there are 30 videos. The reason why we used so many videos was to create an approximate environment of a common advertising time on the TV, where normally more than 6 ads are shown.

Table II Distribution of the TV commercials between the five blocks.

Block 1	Block 2	Block 3	Block 4	Block 5
Sagres 1	Vodafone 2	CTT 2	Optimus 1	CTT 1
Bom Petisco 1	Galp 1	Millennium BCP 2	CGD 1	Absolut Vodka 1
Millennium BCP 1	CGD 2	Licor Beirão 2	Delta Cafés 1	Optimus 2
Nespresso 1	Licor Beirão 1	Martini 1	Superbock 1	Martini 2
Fanta 2	Delta Cafés 2	Nespresso 2	Bom Petisco 2	Fanta 1
Vodafone 1	Sagres 2	Sumol 2	Absolut Vodka 2	Superbock 2

We felt it was also important to build a table with a brief description of each video used (seeTable III).

Table III Brief description of each ad.[7]

	Block 1	Block 2	Block 3	Block 4	Block 5
DESCRIPTION	**Sagres 1** Sexy commercial. Interaction between beautiful girl and the product.	**Vodafone 2** Appeals to summer. Comedians.	**CTT 2** Good music. Educational video.	**Optimus 1** Funny, a big finger pushing people. Interesting music.	**CTT 1** Very educational, appealing to cognition.
	Bom Petisco 1 Sexy ad. Funny and with a good slogan at the end. Bad quality of the video though.	**Galp 1** Girl interacting with product.	**Millennium BCP 2** A young guy doing parkour. With a non expected end.	**CGD 1** Emphasis on the storyline. Quality of video not so good.	**Absolut Vodka 1** Innovative, creative on some frames. Brazilian voice.
	Millennium BCP 1 Very cognitive video. Speaking by an off-voice through all the video.	**CGD 2** In the desert. Recalls Dakar.	**Licor Beirão 2** Humoristic. Appeals to a "healthy" patriotism.	**Delta Cafés 1** Funny. An intentional imitation of the Nespresso 1 ad.	**Optimus 2** Girl speaking, interacting with the product. Young, use of slang.
	Nespresso 1 With a famous actor. A well known commercial. Funny ad.	**Licor Beirão 1** Young. Remembers summer. Quality not very good.	**Martini 1** Old commercial and an icon of martini. James Bond style. Bad quality's video.	**Superbock 1** Emphasis on the music. Young and dynamic.	**Martini 2** Famous actor on the ad. Funny, with a good sequence of actions.
	Fanta 2 A cartoon ad. Funny and creative. No speaking language.	**Delta Cafés 2** Humorist.	**Nespresso 2** Funny. Again with a famous actor.	**Bom Petisco 2** Traditional. About a place in Portugal. Traditional music.	**Fanta 1** Use of cartoons. Reminds of the summer. Use of colourful colours.
	Vodafone 1 Dynamic, good soundtrack. Vigorous storyteller.	**Sagres 2** In the beach. Sexy. Girl interacting with product.	**Sumol 2** Numerous young people speaking at different frames. Young and funny.	**Absolut Vodka 2** Very esthetical. Not much action. Boring.	**Superbock 1** Party time. Young. Dynamic.

[7] This table just contains a brief and somehow personal description of the videos. Professional help on the description of the ads can be useful and important in future researches.

2.3.1 Discussion of the paradigm

One could argue that there are too many videos, but studies in neuromarketing with ads usually use that amount of videos or even more, to work as distracters to the ones that they want to study (Rossiter, Silberstein et al. 2001; Astolfi, Fallani et al. 2009; Ohme, Reykowska et al. 2010). The use of a cross as an inter-stimulus it is fully documented in the literature. But there have been some doubts about it, claiming that the cross can induce self-reflexive thoughts (Iacoboni, Lieberman et al. 2004). The fact is that the majority of the studies still use a cross as an inter-stimulus achieving good results. About using only 6 seconds duration we based our choice on the fact that the inter-stimulus is only needed for the baseline correction, and this correction only need at maximum 1 second.

2.4 Correction and Filters

Here we will describe the corrections, and filters used in all the recordings. First off, during the recording, the software we used performed an online filter, rejecting the 50 Hz, corresponding to the frequency of the electricity in cables. Then we did Raw Data Inspection excluding all amplitudes in the recording lower than 0.5 μV. In this step no trial had this type of artefact. Thirdly we used an infinite impulse response (IIR) filter, the Butterworth Zero Phase filter type, with low cut-off of 0.3 Hz, time constant of 0.5305 seconds and 24 dB/octave, and with high cut-off of 40 Hz and 24 dB/octave. After the filters we used an Ocular Correction ICA, allowing the correction of the artefacts due to eye movements like blinks and saccades. We used this algorithm in a semi-automatic mode, so we would always see first what was going to be eliminated. This is crucial because sometimes these algorithms can eliminate components of the EEG that are necessary. After that we applied an Artefact Correction. Finally we applied a Baseline Correction on the segments. The baseline correction uses the points of the inter-stimulus and subtracts from the segment of the stimulus.

2.4.1 Discussion of corrections and filters used

Some of the steps mentioned here deserve some discussion. If there were amplitudes lower than 0.5 μV we wanted to exclude them because generally they are due to bad electrode placement. Because the EEG frequencies of interest are between 1 Hz and 40 Hz, particularly Theta waves (4 to 7 Hz), Alpha waves (8 to 13 Hz) and Beta waves (14 to 25 Hz) (Niedermeyer and Lopes da Silva 2005), we used an FIR filter with the details given before. The reason why we used an IIR filter was mostly because if we used the finite impulse response (FIR) filter the computation time of this step would be much longer. A FIR filter is a discrete-time filter that settles to zero all after N+1 samples, whereas the IIR filter has an impulse response that is non-zero over an infinite length of time. The FIR filter has some properties that can make it preferable to an IIR filter. However, the computation time required, especially when filtering low frequencies (like in our case), is far greater than the IIR filter computation time. In our study we used the Butterworth filter, which was first described by Stephen Butterworth (Butterworth 1930). Anyway, results with these filters are pretty satisfactory. Most important is the fact that muscle artefact is typically higher than 40 Hz being easy for this filter to attenuate them, which in experiences like this one sometimes it is impossible to avoid muscle artefacts.

Eye moving artefacts can be a major issue in the voltages recorded on some electrodes. About 0.20 of the voltage due to eye movement reaches the Fz, decreasing to about 0.05 at occipital electrodes (Croft and Barry 2000). Some approaches can be used to control this artefact, like telling the subjects to not move their head and eyes, by fixating the centre of the monitor. Nevertheless, some researchers reported this imposition may affect the N1 and P3 components of an event related potential (ERP) (Croft and Barry 2000). Additionally, the use of filters for correction of the signal is required. There are two options: use of a regression-based or component-based model (Croft and Barry 2000; Wallstrom, Kass et al. 2004). Traditionally, the common methods used are the regression-based, (Gratton, Coles et al. 1983), but they raise come concerns about bidirectional contamination. Brain electrical activity may also contaminate the electrooculogram (EOG) recordings, so when applying these methods cerebral activity of interest may be eliminated too (Wallstrom, Kass et al. 2004). We opted to use a component-based model, the Independent Component Analysis (ICA). ICA is a computational method that separates a multivariate signal into additive subcomponents that are statistically independent (Vigário 1997; Joyce, Gorodnitsky et al. 2004). The algorithms used in ICA have been shown to be able to correctly extract information from the EOG signal, without using the components of brain activity present. Thus, ICA is able to remove eye movement artefacts better than some traditional methods (Vigário 1997). Another advantage is that it could be used in semiautomatic mode. Although some researchers refer to this as a disadvantage (Joyce, Gorodnitsky et al. 2004), in our case it allowed us to have a better control on what was being eliminated.

3. Results and Discussion

This chapter will be divided into the three analyses we have done, where in each section the most important results will be presented and discussed.

3.1 Spectral Analysis

The first analysis of the recorded electroencephalograms consisted of the spectral analysis of some of the commercials. The TV commercials used on this analysis were chosen based on the answers given by the participants in the final questionnaires.

We did a basic statistic analysis of the questionnaire about the TV commercials that the subjects saw, obtaining a box plot that gives for each TV commercial the mean and the standard deviation of the scores received (see Figure 7). We then get histograms for all the TV commercials (see in Appendix B). With these histograms it was easy to see the ones with the best scores and the worst. The best ad was the Licor Beirão 2 (see Figure 8) that had the best mean (4.125), and the worst was Optimus 2 (see Figure 9), that had the worst mean (2.625). We also did a paired t-test for all the ads. And as expected it was between the ads Licor Beirão 2 and Optimus 2 that greater mean difference was observed with a very significant statistical value (see Table IV).

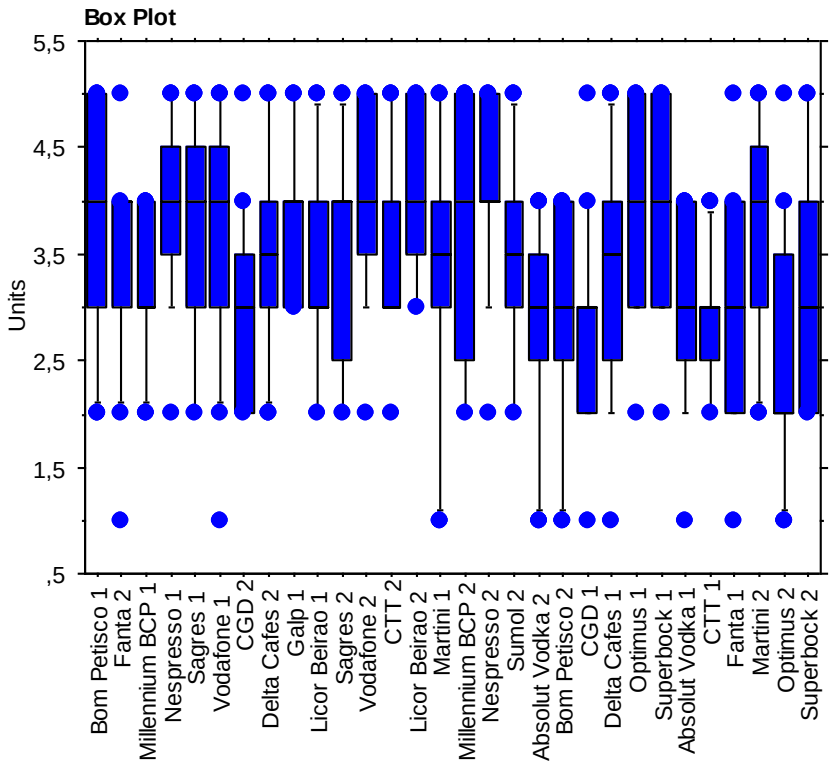

Figure 7 Graphic showing for each TV commercial shows the 10th (lower extreme), 25th (lower quartile), 50th (median), 75th (upper quartile) and 90th (upper extreme) percentiles, and the dots are values above the 90th or below the 10th.

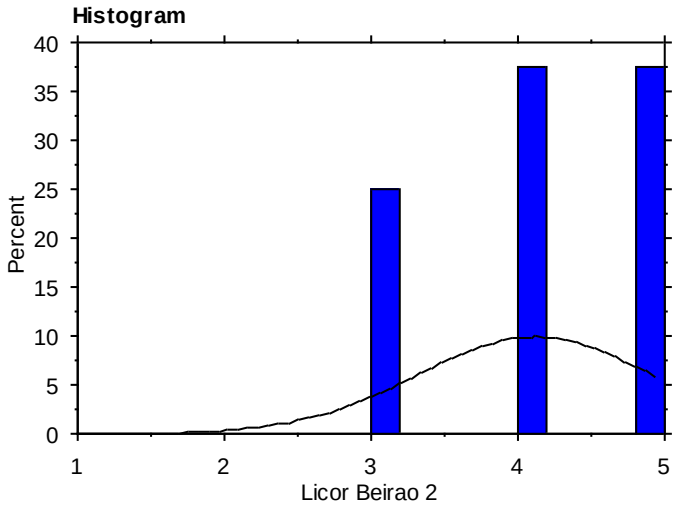

Figure 8 Representation of the distribution of the scores given for the ad Licor Beirão 2.

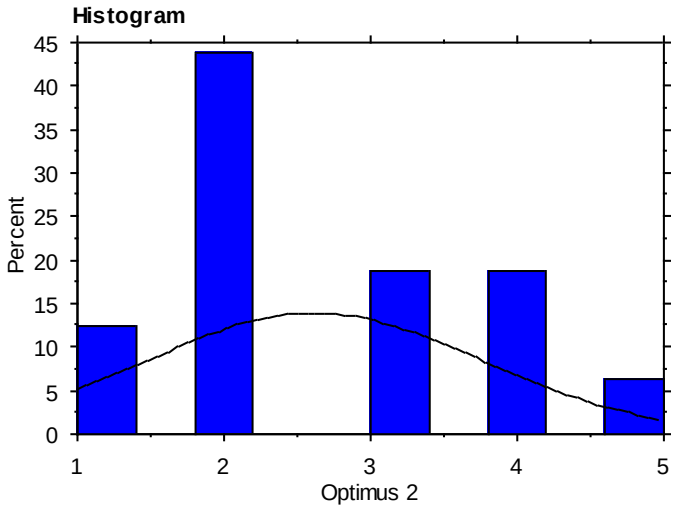

Figure 9 Representation of the distribution of the scores given for the ad Optimus 2.

Table IV Values of the t-test between the ads Licor Beirão 2 and Optimus 2.

	Mean difference	DF	t-Value	P- Value
Licor Beirão 2, Optimus 2	1.7502	19	6.254	<0.0001

The paired t-test is used for comparison of two measurements from the same individual or experimental unit. In this situation the two measurements are the two ads. This statistical analysis tests the hypothesis that the mean difference between pairs of measurements is equal to zero (i.e. that they were equal). When a small p-value (<0.05) is reported it means that the existing mean difference between the pair is unlikely due to chance, so the two groups are likely be different. In the results shown in the table IV it is exactly this that happens.

Hence, for this first analysis we studied two ads that according to the questionnaire were the most opposite and had different responses (Licor Beirão 2 and Optimus 2). We applied a Fast Fourier Transform with a Hanning window of length 10%, with a resolution of 0.031 Hz, giving us the power (μV^2) of each frequency. The software we worked with allowed us to create brain mappings of the frequency spectrum (see Figure 10 and Figure 11). We then elaborated a table explaining where the frequency bands are being activated, so we could see the main differences between each TV commercial (see Table V).

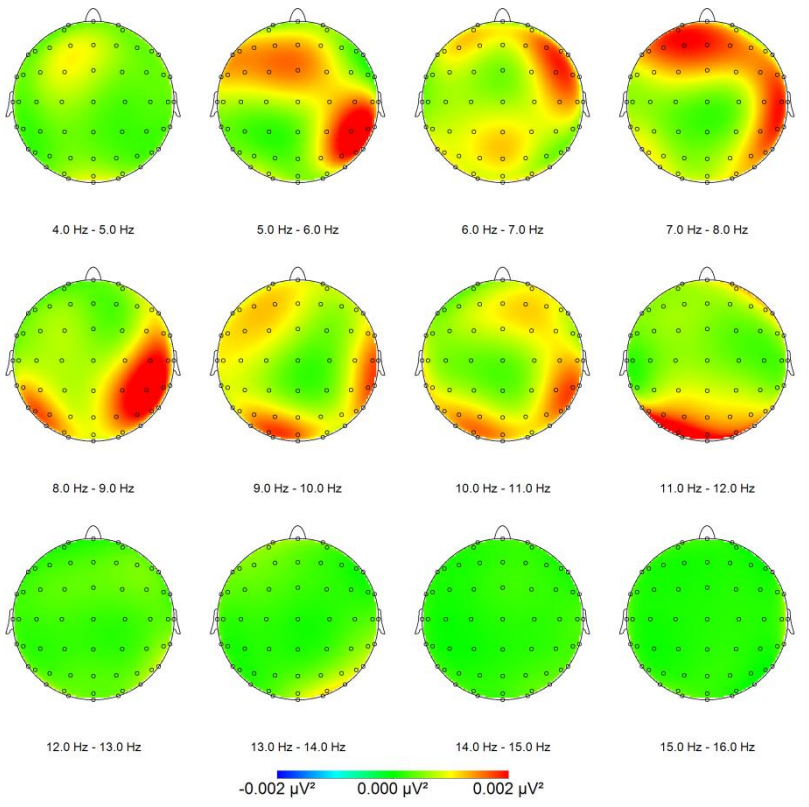

Figure 10 Brain mapping of frequencies for the average of the participants who gave positive scores for the ad Licor Beirão 2.

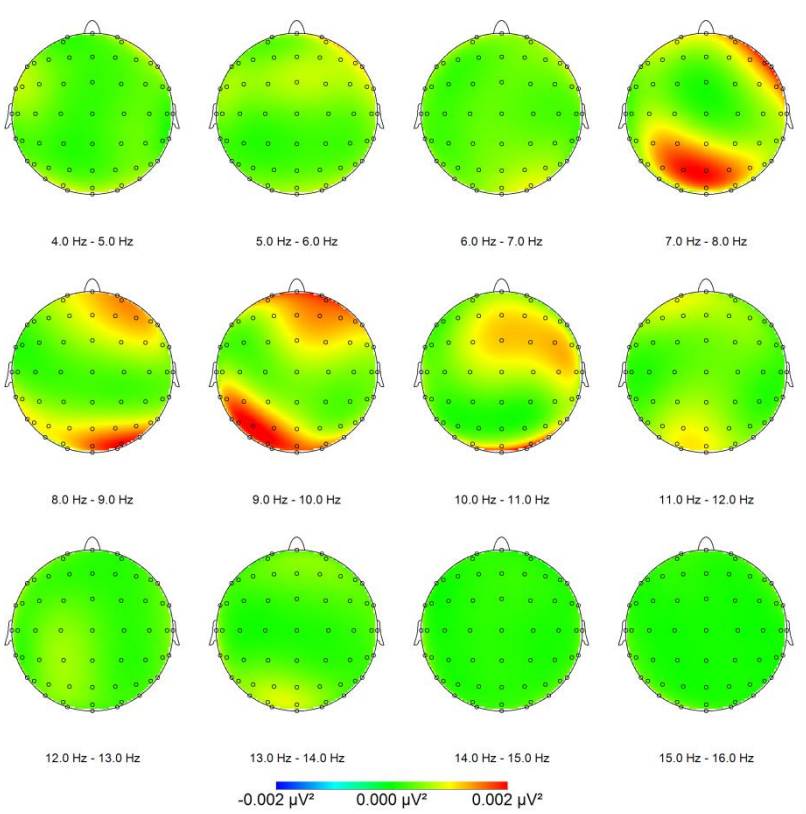

Figure 11 Brain mapping of frequencies for the average of the participants who gave negative scores for the ad Optimus 2.

Table V Description of the figures 9 and 10, naming the regions where frequencies were observable.

Frequencies / Ads	[4 a 8[/ Hz	[8 a 14[/ Hz	[14 a 16] / Hz
Licor Beirão 2	5 Hz to 6 Hz frequencies are present in the left frontal electrodes, and in the right temporal electrodes. From 6 Hz to 7 Hz are more activated in the right frontal electrodes. 7 Hz to 8 Hz occur mainly in the frontal electrodes and in the right temporal electrodes.	Big activation of the low rhythms of alpha waves in the occipital region, with right lateralization. Some frequencies are also present in right temporal electrodes and in left frontal electrodes.	No significant activity
Optimus 2	Very low activation of high rhythms of theta waves (7 to 8 Hz) in prefrontal region with right lateralization and in occipital region.	Low rhythms (8 to 10 Hz) of alpha waves in occipital region and in right prefrontal region. A low activation of higher rhythms in occipital regions and right frontal regions.	No significant activity

By visualizing the brain mapping of the frequencies, we can see that the video Licor Beirão 2 has a bigger activity of the theta waves in the midline frontal. According to Aftanas and Pavlov (2005) theta activity is related with increased approach-related behaviour and working memory. Theta waves have long been associated with emotional processes. Some studies conducted with children have shown

that rhythms of 4 Hz seemed to be related with pleasure. However they do not have been reported in the adult EEG (Niedermeyer and Lopes da Silva 2005). Further information about theta waves will be given later, but for now it is important to retain that indeed it is believed that theta waves are correlated with emotions and limbic regions. As we can see for the ad Optimus 2 no significant theta activity occurs. This was somehow expected as the ad Optimus 2 received the worst scores and the ad Licor Beirão 2 the best. As for the alpha band, the ad Licor Beirão 2 has more activity in all the spectrum of the band, nonetheless for both ads there is alpha activity majorly in occipital regions. It is believed that the origin of alpha rhythms can be localized in the primary and secondary visual areas of the occipital cortex (Feige, Scheffler et al. 2005). So it is expected to see occipital alpha rhythm, but how the visual stimuli used influences that activity is still unclear. The amplitude of those rhythms do not only depend on visual stimulation, but also on visual imagery, vigilance, and visual attention, moreover which structures are responsible for alpha rhythm fluctuation and their role is not yet described (Feige, Scheffler et al. 2005).

So far we have successfully observed theta activity in medial and frontal cortex for the TV commercial Licor Beirão 2 that according to the questionnaire had the best score. We have with this analysis obtained a result that is correlated with a traditional marketing research method (questionnaire), thus achieving partially one objective we had proposed: obtain validation for the use of EEG in marketing research.

Additionally we analysed the second questionnaire (brand evaluation). Like in the previous one we did some basic statistics. We obtained a box plot (see Figure 12), and histograms for all the brands and the scores given (see in Appendix C).

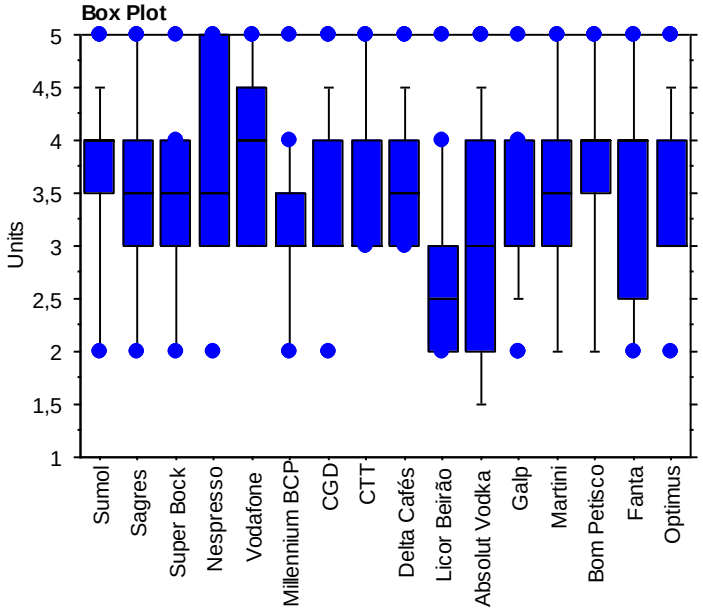

Figure 12 Graphic that for each brand shows the 10th (lower extreme), 25th (lower quartile), 50th (median), 75th (upper quartile) and 90th (upper extreme) percentiles, and the dots are values above the 90th or below the 10th.

We also selected one brand that received extreme scores, and saw the differences of the frequencies activated in the brain scalp. By visualizing the histograms, Sagres was a perfect case for extreme scoring, with four participants giving maximum score (5) and other four giving a low score (2) (see Figure 13). We divided these 8 participants into two groups: the ones who liked the brand Sagres (LS) and the ones who dislike the brand Sagres (DLS). We obtained for the Sagres 1 video for the participants that gave the best scores and the worst scores the following brain maps of frequencies represented in the Figure 13 and Figure 14.

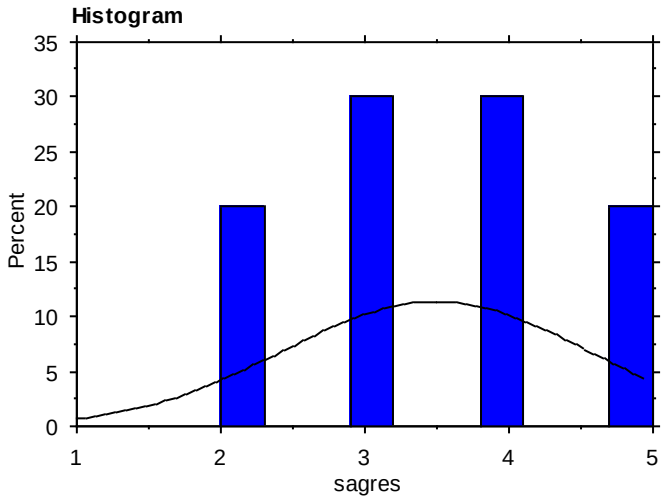

Figure 13 Representation of the distribution of the scores given for the brand Sagres 1.

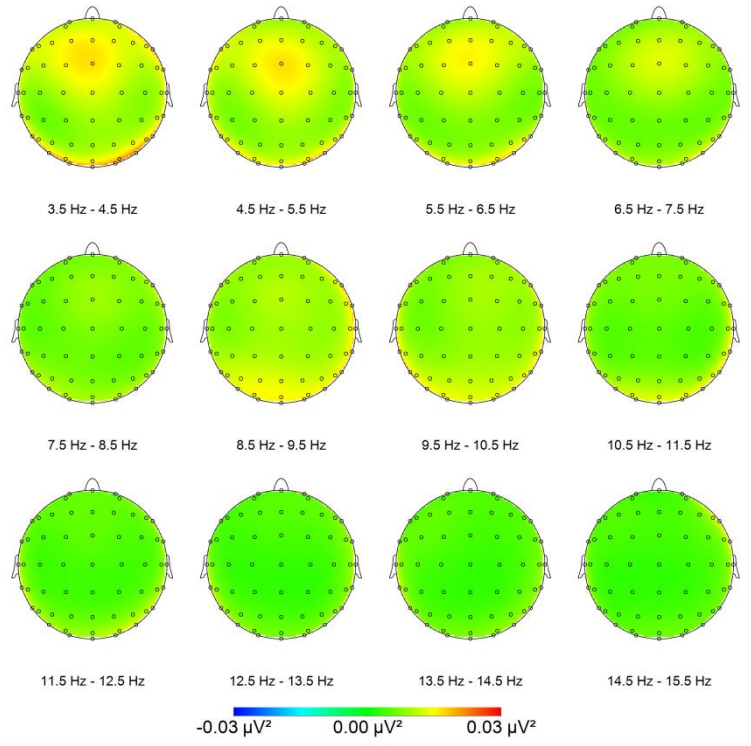

Figure 14 Brain mapping of frequencies for the average of the LS group for the ad Sagres 1.

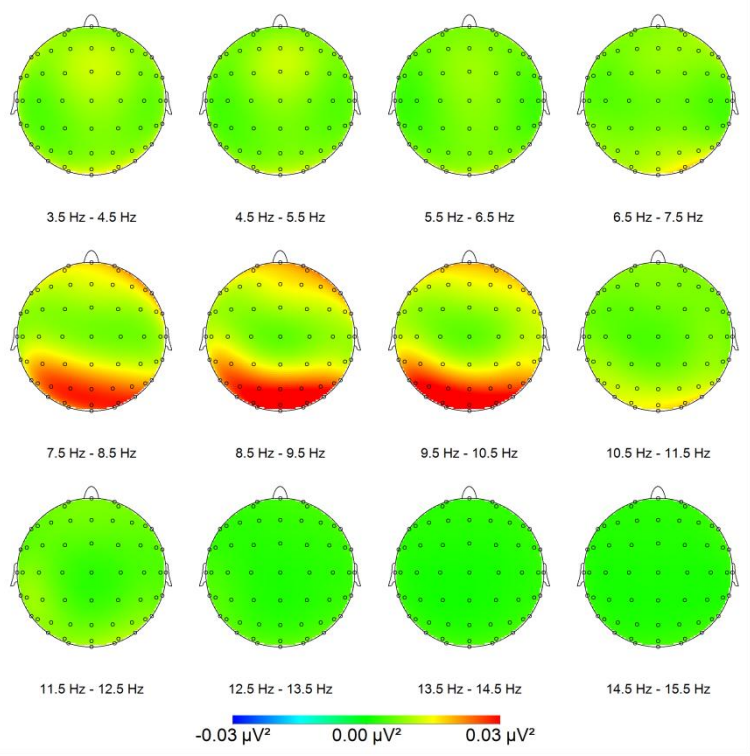

Figure 15 Brain mapping of frequencies for the average of the DLS group for the ad Sagres 1.

We also created a table describing the distribution of frequencies on the cortex of the brain (see Table VI).

Table VI Description of the figures 13 and 14, naming the regions where were viewed the frequencies activity.

Frequencies / Ads	[4 a 8[/ Hz	[8 a 14[/ Hz	[14 a 16] / Hz
Sagres 1 (LS)	Very low distribution of theta waves in medial frontal region.	Very low distribution of alpha waves in the occipital region.	No significant activity
Sagres 1 (DLS)	Very low theta waves.	High distribution of low rhythms of alpha waves in occipital cortex.	No significant activity

With this analysis we intended to infer if there would be any significant difference in the brain maps between the participants who dislike and like the brand Sagres when viewing an ad from the brand. We observe only significant differences in the alpha band. The group DLS had greater activity in the occipital cortex for the alpha rhythm. As mentioned previously the alpha rhythm origin is believed to be the occipital cortex, for visual areas. Moreover it is known that alpha rhythm is related with decreasing of information processing (“idling rhythms”) (Feige, Scheffler et al. 2005). So we can interpret these results by saying that the group DLS had less attention to the ad and was not so interested when

watching it resulting in the increasing of alpha rhythms in the occipital cortex. However, one thing we should have in mind before coming up with conclusions is the group size. For this brand each group had only four participants.

Moreover, at this instance, one could wonder about the alpha occipital activity observed for the ad Licor Beirão 2 and Optimus 2? First, we should highlight that the scale is smaller for brain mapping images obtained for the ads Licor Beirão 2 and Optimus 2 (-0.02 μV to 0.02 μV) than the scale used for Sagres. So when comparing the images we cannot state that the level of alpha activity was the same for both analyses. Furthermore, there are differences in the spatial distribution of the alpha activity. For the case of Sagres, alpha activity is mainly occipital with no lateralization, and for the other two there are slight differences. At what level do these region differences affect information processing is still unclear. Once again we should also mention that the number of subjects used for both analyses is very different (12 and 9 for Licor Beirão and Optimus, respectively).

The second part of this analysis was done by joining the information of the two questionnaires. We did a table where information of the two questionnaires would be somehow visible and able to be interpreted. We performed for each TV commercial an unpaired t-test. By dividing the participants into three groups according to the scores given to the evaluation of the brand: dislike (DL) <3, like (L) >4 and indifferent (I) =3; we then perform an unpaired t-test based on the scores that each of these groups gave to each ad. We present in Table VII the most interesting results (see in Appendix D the rest).

Table VII Unpaired t-test comparing for each ad the scores that the three groups (Dl, I and L) gave.

Ad	Groups	Mean Difference	DF	t-Value	P-Value
Sagres 1	DL, I	-0.933	6	-0.997	0.3574
	DL, L	-1.458	9	-3.434	0.0075
	I, L	-0.525	11	-0.879	0.3982
Sagres 2	DL, I	-0.267	6	-0.455	0.6652
	DL, L	-1.667	9	-4.523	0.0014
	I, L	-1.400	11	-3.572	0.0044
Licor Beirão 1	DL, I	0.167	10	0.415	0.6867
	DL, L	-0.833	8	-1.229	0.2541
	I, L	-1.000	8	-1.549	0.1599
Licor Beirão 2	DL, I	0.333	10	0.674	0.5155
	DL, L	-0.167	8	-0.351	0.7348
	I, L	-0.500	8	-0.980	0.3559
Super Bock 1	DL, I	-0.333	5	-0.378	0.7210
	DL, L	-1.667	10	-2.685	0.0229
	I, L	-1.333	11	-3.004	0.0120

Table VII Unpaired t-test comparing for each ad the scores that the three groups (Dl, I and L) gave. [1] there is no P-Value because the mean difference between the two groups was zero. [2] the group DL had only one participant and more than two is necessary to make this test. (Continued)

Ad	Groups	Mean Difference	DF	t-Value	P-Value
Super Bock 2	DL, I	-1.000	5	-1.195	0.2856
	DL, L	-1.667	10	-2.795	0.0190
	I, L	-0.667	11	-0.983	0.3466
Absolut Vodka 1	DL, I	-0.333	8	-0.464	0.6549
	DL, L	-0.333	7	-0.350	0.7363
	I, L	0.000[1]	11	0.000[1]	-[1]
Absolut Vodka 2	DL, I	-0.048	8	-0.056	0.9566
	DL, L	-0.333	7	-0.577	0.5818
	I, L	-0.286	11	-0.504	0.6243
Optimus 2	DL, I	-0.667	8	-[2]	-[2]
	DL, L	-0.500	5	-[2]	-[2]
	I, L	0.167	13	0.258	0.8003
Martini 1	DL, I	-1.800	5	-2.196	0.0795
	DL, L	-2.778	9	-3.878	0.0037
	I, L	-0.978	12	-1.728	0.1097

Like the paired t-test the unpaired t-test tests compares two groups and determinates the likelihood of the differences occurring by chance. In this analysis we had to use this test because the groups did not have the same dimension.

It is interesting to notice that generally the subjects that dislike the brand tend to give worse scores for the commercials of those brands than the ones that dislike the brand. However, even more interesting to see is that the ads that received better scores do not have such big differences between the groups Dl, I and L. For example, for the ad Licor Beirão 2 the mean difference is only -0.167, which means that in average the group L gave only more 0.167 points than the group DL. This means that this ad is in general more attractive for all the subjects. The ad Optimus 2 has the same behaviour, but with negative scores.

3.2 Asymmetries Analysis

The previous analysis just gave us visual information about differences in frequency bands distributed over the scalp for each video. Now we intend to infer about possible asymmetries on some of the electrodes. We exported from the Brain Analyser, areas of the frequencies power density calculated with the FFT for three different frequency bands (Alpha, Theta and Beta). After that we normalized the data using the natural logarithm function, which can be done because power values are positively

skewed (Davidson, Ekman et al. 1990). Based on Davidson model it is important to see if there are asymmetries in the prefrontal cortex. We first compared the two videos (Licor Beirão 2 and Optimus 2) with a t-test for the alpha band on left frontal electrodes (Fp1, AF3, F1, F3, F5, F7) and on right frontal electrodes (Fp2, AF4, F2, F4, F6, F8) (see Table VIII).

Table VIII Comparison of the average between alpha power of left and right frontal electrodes for the ad Licor Beirão 2 and the ad Optimus 2

	Mean Difference	**DF**	**t-value**	**P-Value**
Licor Beirão's left hemisphere, Optimus' left hemisphere	0.637	19	10.708	<0.0001
Licor Beirão's right hemisphere, Optimus' right hemisphere	0.631	19	10.666	<0.0001

The results show that, both on the left and right hemisphere, alpha power is higher for the TV commercial of the Licor Beirão 2. According to what we have said already, alpha waves appear when there is a decrease of activation of that brain region. By only focusing our discussion on these results we could say that there was less activation of the frontal cortex when participants were watching Licor Beirão video. However further analysis is necessary. So, we also did a t-test for each video between right and left hemisphere for each frequency band of interest. To do so, we decided to use the average the following frontal electrodes: Fp1, AF3, F7, F5, F3 and F1 and their contralateral electrodes. The results showed that in the alpha band none of the TV commercials had significant difference between left and right hemisphere. As for the theta band and beta band both ads had significant difference, specially the Licor Beirão's ad (see Table IX). Additionally, we did a t-test comparing the differences of the theta power and the beta power between the two videos. In this case we used an average of all the electrodes for both wave rhythms (see Table X).

Table IX – Values given by the t-test between frontal electrodes of the left hemisphere (Fp1, AF3, F1, F3, F5, F7) against the electrodes of the right hemisphere (Fp2, AF4, F2, F4, F6, F8), for each frequency band of interest and each ad.

		Mean Difference	**DF**	**t-value**	**P-Value**
Alpha	Licor Beirão 2	-0.017	19	-1.533	0.1418
	Optimus 2	-0.022	19	-1.632	0.1191
Theta	Licor Beirão 2	-0.036	19	-2.691	0.0145
	Optimus 2	-0.038	19	-2.257	0.0360
Beta	Licor Beirão 2	-0.069	19	-2.545	0.0197
	Optimus 2	-0.038	19	-2.382	0.0278

Table X Values given by the t-test of the average of the theta power and of the beta power in all electrodes between the two ads

		Mean Difference	DF	t-value	P-Value
Theta	Licor Beirão 2, Optimus 2	0.525	19	9.799	<0.0001
Beta	Licor Beirão 2, Optimus 2	0.954	19	15.017	<0.0001

According to Davidson model, left-sided activations would be associated with approach and right-sided with withdrawal. However, another valence exists, positive vs. negative affect, and those are not predicted by this model (Davidson, Ekman et al. 1990; Davidson and Irwin 1999). For example, a positive affect like amusement does not necessary means an approach-related reaction, but anger (a negative affect) is an approach-related reaction (Davidson, Ekman et al. 1990). So, even though no statistical significance was found for the asymmetries on frontal electrodes for the alpha band, that doesn't mean that this work contradicts Davidson's model.

A priori, one should expect that a video scored positively would have a greater left activation when compared with a video that was scored negatively, but as explained that is not entirely true. Firstly, because we do not know what emotions these two videos arouse on the subjects. Secondly, even if we knew we could not say that the positive emotion would provoke an approach-related behaviour and a negative a withdrawal-related behaviour. And at last, some studies have been achieving the same results. Davidson (1990) findings showed that with all data averaged across the entire video, either positive or negative, are not reliably distinguished with EEG asymmetry. What could have been done was to divide the videos in sub-parts and try to infer exactly what emotion or emotions those sub-parts provoke on the participants (whether by questionnaires or facial EMG).

As it was mentioned, one of the goals proposed is to make a "connection" between traditional methods in marketing and the EEG, as a neuroscience tool. Because of it, it was decided to study frontal asymmetries as an approach-withdrawal response analysis. Moreover, one of the quests of advertising research is to improve the impact of an advertisement, and to make it more effective. If it was possible to infer about an approach-related reaction of the participants to an ad, it could be also be possible to infer about its effectiveness. Frontal asymmetry turns out to be a good method in diagnosing the potential of advertising in creating approach reactions (Ohme, Reykowska et al. 2010). Joining the theories of the two models, Davidson's model and HERA model, is the next step on the interpretation of the results. If Davidson's model says that left frontal cortex is responsible for approach-related reactions and HERA model that the left frontal cortex is fundamental in processing information into long-term memory (Tulving, Kapur et al. 1994), we can confirm that an ad that would create an approach reaction would be also more memorable. However, HERA model is not free of

controversy, since some researchers still report an important role in encoding of the right frontal cortex (Ohme, Reykowska et al. 2010), and it is believed that the right cortices are fundamental in storing images (Astolfi, Fallani et al. 2008). Nevertheless, because our procedure was not built so we could study these issues, we will not infer about the validity of this model. If we wanted to further investigate this model we should have another procedure that would ask the participants (e.g. one week later) which ads they remembered. For example, in our study it was impossible to use ads that had not be shown in Portuguese TV, so if subjects have seen or not the ad, and have remember it or not is unknown. This is also another reason for the fact that we did not see dominance in frontal areas, as the group of participants may have outliers (subjects who saw it for the first time, and subjects who had already seen and remembered it).

One last result worth mentioning is the theta and beta powers for the average of all electrodes. It is interesting to find that both theta and beta have a greater activity when subjects were watching the Licor Beirão's ad. As mentioned, theta waves have been correlated with emotions and limbic regions of the brain. Slow waves like theta are related with processes like emotion and memory. In particular, theta activity in the midline frontal is related with low anxiety and increased approach-related behaviour, and with working memory (Aftanas and Pavlov 2005). The septo-hippocampal complex is responsible for the generation of theta frequencies (Schutter and van Honk 2006). So if in fact the video of Licor Beirão 2 was perceived has having more emotional content this could explain the results. Furthermore, theories like MAC theory suggest that emotion plays an important role on the memorization. Therefore, if an ad appeals more to the emotions ("affect") that ad would be also better remembered. Once again further questionnaires would be necessary to explore this theory. As for beta waves, they are related to alertness, focus, and task management (Young 2002). This shows us that the video of Optimus did not receive as much attention as the video of Licor beirão, and thus possibly explaining the disparity of scores. However, further attention to this matter will be given when analysing the data with LORETA.

As in the previous section, asymmetries for the brand Sagres were studied, choosing the commercial Sagres 1. The same initial procedure of exporting and normalizing done for the previous ads was employed here. First, between the subjects who classified the brand negatively and positively (the DLS and LS groups defined previously) we performed a t-test for the alpha band in the right frontal electrodes and left frontal electrodes (see Table XI). Because we knew by previous experience that asymmetries in the alpha band would not be relevant when doing an analysis where we would average all data from the commercials, we decided to do just these simple analyses of the dominance of alpha power. As shown in the table no statistical significance was found between the two groups, although there is a positive mean difference between the DLS and DL groups.

Table XI Comparison of alpha power activity in left (Fp1, AF3, F1 and F3) and right (Fp2, AF4, F2 and F4) frontal electrodes for the groups Didn' Like Sagres (DLS) and Like Sagres (LS)

	Mean Difference	DF	t-value	P-Value
Fp2 DLS, Fp2 DL	0.330	3	1.598	0.2084
AF4 DLS, AF4 DL	0.261	3	1.273	0.2928
F2 DLS, F2 DL	0.211	3	1.118	0.3451
F4 DLS, F4 DL	0.215	3	1.074	0.3617
Fp1 DLS, Fp1 DL	0.332	3	1.711	0.1856
AF3 DLS, AF3 DL	0.250	3	1.204	0.3151
F1 DLS, F1 DL	0.185	3	0.968	0.4043
F3 DLS, F3 DL	0.188	3	0.920	0.4254

Unlike the analysis of the ads Licor Beirão 2 and Optimus 2, in this analysis we are using the same condition but comparing different subjects. Although the P-Value is not significant, there is a greater activity of alpha waves in frontal electrodes on both hemispheres for the group that didn't like the brand, which would mean less activity in frontal regions for that group. The same references to the group size explained earlier are applicable to this case.

Again, only this analysis cannot give enough reliable results to infer about the differences between the perception of an ad when watched by a participant who liked and who didn't liked. So we also studied the statistical difference between the theta power and the beta power between the two groups (see Table XII).

Table XII Values given by the t-test of the average of the theta power and of the beta power in all electrodes between the two groups

		Mean Difference	DF	t-value	P-Value
Theta	DLS, DL	-0.087	3	-1.575	0.2134
Beta	DLS, DL	-0.185	3	-1.072	0.3623

Like before, although the mean difference is as expected (more theta and beta waves for the group that liked the brand), the P-Value is bigger than 0.05 and therefore no statistically significant information can be extract from the table. It is only feasible to make assumptions based on the possibility that more participants would do the experiment and that the mean difference would remain the same. If these happened, confirmation that a person who does not like a brand has less emotional brain structures being activated when watching an ad from that brand than a person that likes the brand would be possible to make. Of course this is a strong statement. But studies, like McClure, Li et al. (2004), concluded that knowing a brand and having preference for that brand can override the sensory information. The work mentioned used two familiar cultural drinks, and showed that when not knowing the brand structures responsible for sensory information processing were more activated, but when the brand was showed other structures were more activated, like the DLPFC and midbrain.

3.3 LORETA analysis

In the previous analysis we found out that those asymmetry studies with TV commercials were not enough to obtain a reliable result about the effectiveness of the advertisements. In this last analysis we used the method Low Resolution Electromagnetic Tomography (LORETA) by resorting to the software sLORETA (available free online) developed by the "father" of this method, Roberto D. Pascual-Marqui and his co-workers (Pascual-Marqui, Esslen et al. 2002). With this analysis we are interested in finding the differences between two ads with extreme scores, one with the best ones and another with the worst. Like before we chose the Licor Beirão 2 and Optimus 2 commercials. We contrast the regions of the brain being more activated for each ad against an average of one second of the inter-stimuli. This is a standard procedure so we can obtain brain regions that are being more activated comparing with a situation of rest and when the participants hopefully and ideally were not thinking about anything. The average was calculated for each participant, using their EEG signals during the inter-stimulus of six seconds. We segmented each video in intervals of one second, and exported that data to the software. The tutorial of the software guided us through the initial steps. First, we need to transform the electrodes system we use into the Talairach electrode coordinates. Then we can make the sLORETA transformation matrix. We are ready now to perform a tANOVA. This step is essential to see when the two experimental conditions (during the video and during the inter-stimulus) differ. Only then can we obtain the images of the sLORETA that indicate what regions of the brain are being more activated when compared to the inter-stimuli.

Before presenting and discussing the results we should also discuss one step in particular: the tANOVA analyses. With the high amount of data we acquire with 64 channels, a sampling rate of 500 Hz and the 30 seconds of each video (although we segmented the video in intervals of 1 second), it is highly probable that by stochastic processes some of the data matrix values would meet the 0.005 criterion of statistical significance when comparing two experimental conditions. Thus, it is important to be sure to find the values that are significantly different but not by chance. The solution is topographic mapping of the EEG. It is of extreme importance to analyze the topography of the scalp electric field before trying to localize the brain sources. This method gives statistical information about response strength, latency, and more importantly topographic, giving additional information and

neurophysiologic basis (Murray, Brunet et al. 2008). With the tANOVA we confirmed that the seconds we shown had statistical significance.

We started by analysing the video of Licor Beirão. We decided to show only three moments. These moments were considered to be the key instants of the ad. By previous knowledge, we already know that the initial, final and the moments with the product are the most important in the recognition of an ad (Astolfi, Fallani et al. 2008). Based on this we selected the first second, one second that would go from 3000 ms to 4000 ms and a second that would go from 2500 ms and 2600 ms (see Figure 16). For the moment from 2500 ms to 2600 ms we also showed brain activations in a slice view (see Figure 17).

Additionally, we show in the Table XIII the brain regions that were activated with significant p-value (<0.05) for the first 5 seconds of the ad and 7 seconds where the brand was shown on the video.

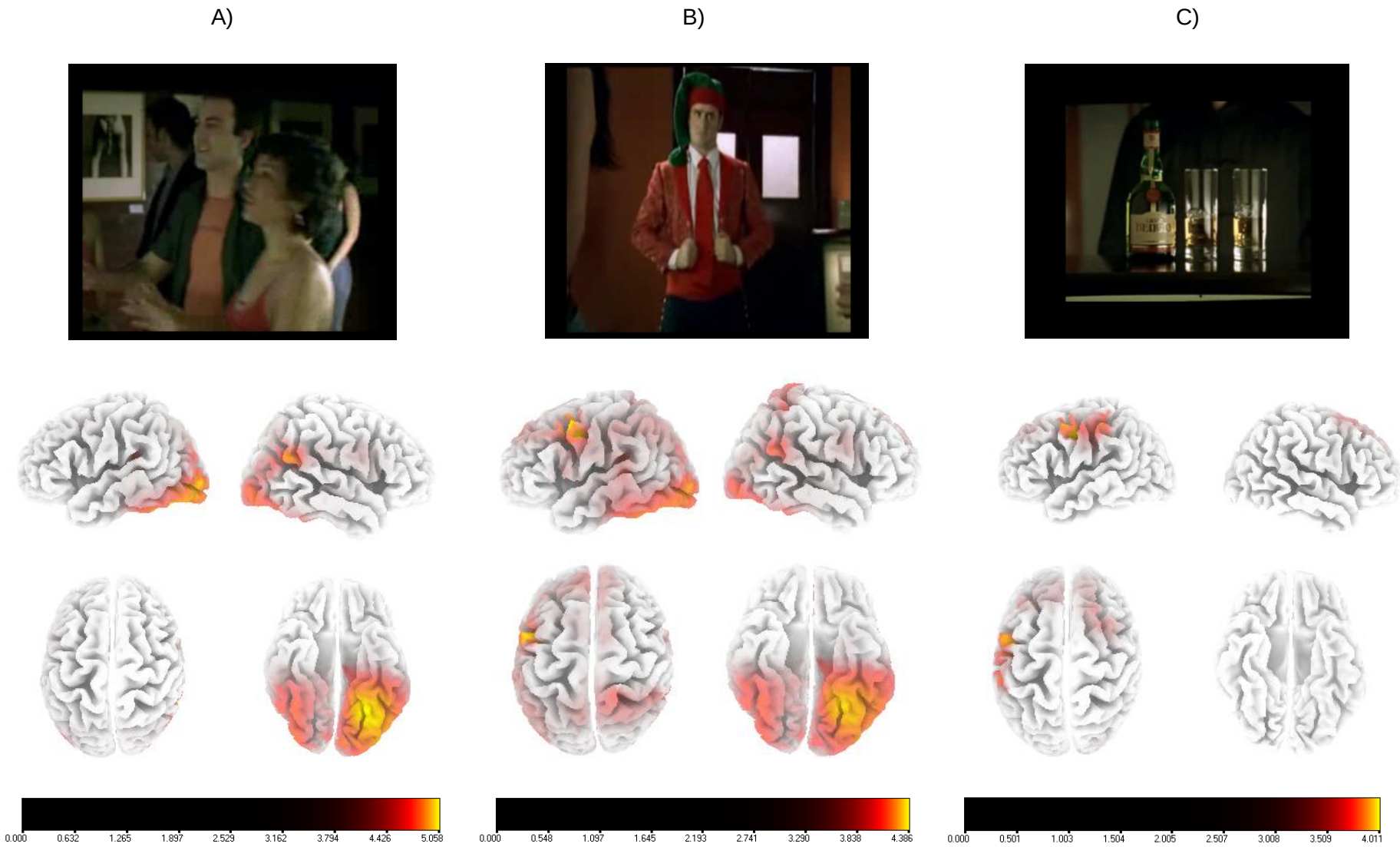

Figure 16 3D images of the cortex with the regions being more activated for the three moments. Each moment is represented by a frame. A) First second of the ad. On the top a frame take from that second and on the bottom a group of four views of the cortex (left, right, top, bottom, from the left top to the right bottom). This structure is common to the following sub-parts of the figure. B) From the 3rd second to the 4th of the ad. C) From the 25th second to the 26th second of the ad.

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
0-1000	3.981	Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-25,-60,-15) [5.05848] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,-10) [5.04102] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (-35,-55,-15) [5.01442] Occipital Lobe, Lingual Gyrus, Brodmann area 19 (-25,-65,0) [5.00827] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (-40,-90,0) [5.00181]	Temporal Lobe, Supramarginal Gyrus, Brodmann area 40, (65,-50,25) [4.92937] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 22 (65,-50,20) [4.85793] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 19 (45,-85,-5) [4.84158]	Occipital Lobe, Lingual Gyrus, Brodmann area 18 (0,-90,-15) [4.78899]
1000-2000	3.036	Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (-35,-70,45) [4.06526] Parietal Lobe, Precuneus, Brodmann area 19 (-35,-70,40) [4.05693] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (-40,-65,45) [4.03612] Sub-lobar, Insula, Brodmann area 13 (-50,-35,20) [3.97216] Temporal Lobe, Angular Gyrus, Brodmann area 39 (-45,-80,35) [3.95503] Frontal Lobe, Precentral Gyrus, Brodmann area 6 (-45,0,40) [3.79457] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 11 (-5,55,-10) [3.64546]	Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (60, -55,25) [3.88686] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 42 (65,-35,20) [3.87794]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,45,30) [3.64008] Parietal Lobe, Precuneus, Brodmann area 7 (0,-55,60) [3.63252]
2000-3000	2.957	Sub-lobar, Insula, Brodmann area 13 (-50,-35,20) [3.71903] Frontal Lobe, Precentral Gyrus, Brodmann area 44 (-60,15,10) [3.68900] Temporal Lobe, Superior Temporal Lobule, Brodmann area 42 (-55,-35,15) [3.68114] Frontal Lobe, Middle frontal Gyrus, Brodmann area 9 (-45,30,40) [3.59880]	Parietal Lobe, Postcentral Gyrus, Brodmann area 5 (20,-50,70) [3.770839] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (20,-50,65) [3.76475] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-45,55) [3.73376]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 6 (5,40,40) [3.81419] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (10,35,50) [3.79616]

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
3000-4000	3.419	Frontal Lobe, Precentral Gyrus, Brodmann area 6 (-45,0,40) [4.38636] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 8 (-50,5,45) [4.38237] Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-25,-60,-15) [4.35136] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,-5) [4.33646] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (-35,-55,-20) [4.31660] Frontal Lobe, Inferior Frontal Gyrus, Brodmann area 9 (-50,5,35) [4.26813] Limbic Lobe, Uncus, Brodmann area 20 (-30,-15,-35) [3.65952]	Temporal Lobe, Supramarginal Gyrus, Brodmann area 40 (65,-50,25) [4.19116] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (45,-60,-25) [4.17347] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 19 (45,-85,-5) [4.15623] Parietal Lobe, Precuneus, Brodmann area 7 (10,-65,60) [3.70251] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (10,30,35) [3.68126]	Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (5,25,55) [3.71157] Occipital Lobe, Cuneus, Brodmann area 18 (0,-95,5) [3.71034] Frontal Lobe, Paracentral Lobule, Brodmann area 5 (0,-40,60) [3.70166] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (0,35,25) [3.67257] Limbic Lobe, Posterior Cingulate, Brodmann area 30 (-5,-50,20) [3.67163]
4000-5000	3.338	Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-35,-70,-20) [4.22966] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (-40,-60,-20) [4.19532] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,-10) [4.18401] Occipital lobe, Middle Occipital Gyrus, Brodmann area 18 (-40,-90,0) [4.18052] Limbic Lobe, Sub-Gyral, Brodmann area 19 (-15,-45,-10) [4.02990] Limbic Lobe, Posterior Cingulate (-20,-65,5) [4.00561] Occipital Lobe, Cuneus, Brodmann area 18 (-25,-95,-5) [3.95907]	Parietal Lobe, Postcentral Gyrus, Brodmann area 3 (20,-40,70) [4.22703] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (40,-60,-25) [4.18555] Frontal Lobe, Paracentral Lobule, Brodmann area 3 (15,-40,60) [4.17154] Parietal Lobe, Inferior Parietal Lobule, Brodmann area (45,-40,55) [4.09323] Parietal Lobe, Precuneus, Brodmann area 7 (15,-50,60) [4.04351] Parietal Lobe, Precuneus, Brodmann area 7 (10,-50,60) [4.01214]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (-5,45,35) [4.02598] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-5,35,30) [3.88886]

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
21000-22000	3.476	Parietal Lobe, Postcentral Gyrus, Brodmann area 7 (-10,-60,70) [4.35505] Parietal Lobe, Precuneus, Brodmann area 7 (-10,-60,65) [4.31921] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (-40,-65,50) [4.27969] Temporal Lobe, Angular Gyrus, Brodmann area 39 (-45,-80,30) [4.17945] Occipital Lobe, Cuneus, Brodmann area 19 (-15,-95,25) [4.11485] Temporal Lobe, Fusiform Gyrus, Brodmann area 19 (-45,-75,-20) [3.85345]	Parietal Lobe, Postcentral Gyrus, Brodmann area 5 (10,-50,70) [4.36446] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-50,55) [4.33502] Frontal Lobe, Paracentral Lobule, Brodmann area 5 (15,-45,60) [4.33464] Parietal Lobe, Superior Parietal Lobule, Brodmann area 5 (20,-45,65) [4.32369] Parietal Lobe, Sub-Gyral, Brodmann area 7 (20,-50,55) [4.16119] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (55,-55,30) [4.01912] Limbic Lobe, Cingulate Gyrus, Brodmann area 31 (5,-45,45) [3.83795]	Frontal Lobe, Paracentral Lobule, Brodmann area 4 (0,-40,65) [4.10434] Parietal Lobe, Precuneus, Brodmann area 7 (0,-60,55) [4.03340] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,40,35) [3.94185]
22000-23000	3.724	Occipital Lobe, Cuneus, Brodmann area 19 (-10,-95,25) [4.62083] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (-40,-90,0) [4.58787] Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-35,-70,-20) [4.55665] Occipital Lobe, Inferior Occipital Gyrus, Brodmann area -40,-90,-5) [4.54805] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,-10) [4.52421] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (-40,-60,-20) [4.51542] Occipital Lobe, Lingual Gyrus, Brodmann area 19 (-25,-65,-5) [4.52198] Limbic Lobe, Posterior Cingulate, Brodmann area 30 (-20,-60,5) [4.43031] Parietal Lobe, Precuneus, Brodmann area 19 (-30,-85,35) [4.18711]	Occipital Lobe, Cuneus, Brodmann area 19 (5,-95,20) [4.64069] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (50,-60,-25) [4.46508] Occipital Lobe, Inferior Occipital Gyrus, Brodmann area 19 (45,-80,-10) [4.43204] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (35,-90,0) [4.42430] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9, 10 (25,50,25) [4.35300] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9, 10 (25,45,25) [4.34647] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (60,-55,25) [4.20839] Parietal Lobe, Precuneus, Brodmann area 19 (5,-85,40) [4.19199] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-45,55) [4.17264]	Occipital Lobe, Cuneus, Brodmann area 18 (0,-95,15) [4.56747] Occipital Lobe, Lingual Gyrus, Brodmann area 18 (0,-90,-15) [4.29547]

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
23000-24000	4.190	Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-35,-70,-20) [4.99434] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (-40,-90,0) [4.97658] Occipital Lobe, Superior Occipital Gyrus, Brodmann area 19 (-40,-85,20) [4.97487] Occipital Lobe, Inferior Occipital Gyrus, Brodmann area 18 (-40,-90,-5) [4.96154] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,-10) [4.94884] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 19 (-50,-70,-15) [4.92558] Parietal Lobe, Precuneus, Brodmann area 19 (-35,-80,40) [4.90900] Occipital Lobe, Lingual Gyrus, Brodmann area 19 (-15,-65,-10) [4.88939] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (-35,-70,45) [4.86797] Temporal Lobe, Angular Gyrus, Brodmann area 39 (-45,-80,30) [4.85693] Limbic Lobe, Sub-Gyral, Brodmann area 19 (-15,-45,10) [4.80785] Limbic Lobe, Posterior Cingulate, Brodmann area 30 (-15,-60,5) [4.74877] Parietal Lobe, Angular Gyrus, Brodmann area 39 (-45,-75,35) [4.68430]	Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (60,-55,25) [5.18069] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 22 (60,-60,20) [5.10397] Temporal Lobe, Supramarginal Gyrus, Brodmann area 40 (65,-50,25) [5.09845] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (35,-85,-15) [4.82845] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (60,-45,25) [4.80926]	Occipital Lobe, Lingual Gyrus, Brodmann area 18 (0,-90,-15) [4.72367] Occipital Lobe, Cuneus, Brodmann area 18 (0,-85,15) [4.68872]

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
24000-25000	2.747	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (-45,30,40) [3.81423] Frontal Lobe, Precentral Gyrus, Brodmann 9 (-40,25,40) [3.70123] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (-55,-55,45) [3.66751] Parietal Lobe, Precuneus, Brodmann area 19 (-35,-70,40) [3.62947] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (-40,-65,50) [3.62820] Occipital Lobe, Superior Occipital Gyrus, Brodmann area 19 (-40,-85,30) [3.59690] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (-45,-45,35) [3.59616] Temporal Lobe, Angular Gyrus, Brodmann area 39 (-45,-80,30) [3.59425] Sob-lobar, Insula, Brodmann area 13 (-50,-35,20) [3.57787] Parietal Lobe, Angular Gyrus, Brodmann area 39 (-45,-70,35) [3.57027] Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-35,-70,-20) [3.53921] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-35,35,35) [3.51624] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-5,35,30) [3.51301] Frontal Medial Frontal Gyrus, Brodmann area 9 (-5,30,35) [3.48505] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (-35,-90,-5) [3.46934] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-20,-55,-10) [3.46866] Occipital Lobe, Lingual Gyrus, Brodmann area 19 (-20,-70,-10) [3.45023]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (5,35,35) [3.66515] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (5,35,30) [3.62262] Frontal Lobe, Inferior Frontal Gyrus, Brodmann area 9 (50,0,25) [3.61253] Frontal Lobe, Precentral Gyrus Brodmann area 6 (55,0,25) [3.59979] Frontal Lobe, Cingulate Gyrus, Brodmann area 32 (5,25,40) [3.55035] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 6 (10,30,60) [3.51621] Parietal Lobe, Postcentral Gyrus, Brodmann area 7 (15,-55,65) [3.51413] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (5,30,30) [3.50449] Frontal Lobe, Paracentral Lobule, Brodmann area 3 (15,-40,60)	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,35,35) [3.69719] Parietal Lobe, Precuneus, Brodmann area 7 (0,-55,65) [3.47888] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (0,25,35) [3.46972] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (0,35,25) [3.44448] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,35,50)

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
25000-26000	3.037	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (-5,40,35) [3.97111] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-5,50,35) [3.89462] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-5,35,30) [3.82748] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 8 (-45,15,50) [3.80476] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (-5,30,30) [3.63862] Parietal Lobe, Postcentral Gyrus, Brodmann area 7 (-15,-55,70) [3.63770] Sub-lobar, Insula, Brodmann area 13 (-45,-40,20) [3.47486]	Frontal Lobe, Superior Frontal Gyrus, Brodmann area 6 (10,30,60) [3.98742] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (5,30,45) [3.95872] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (15,5,65) [3.86675] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (5,20,50) [3.82493] Parietal Lobe, Postcentral Gyrus, Brodmann area 5 (20,-50,70) [3.74290] Parietal Lobe, Precuneus, Brodmann area 7 (15,-50,60) [3.67061] Parietal Lobe, Superior Parietal Lobule, Brodmann area 5 (20,-45,60) [3.65742] Parietal Lobe, Paracentral Lobule, Brodmann area 4 (5,-40,70) [3.63238] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (35,-50,50) [3.53629]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,40,35) [3.83347] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,30,55) [3.82473] Frontal Lobe, Paracentral Lobule, Brodmann area 5 (0,-45,65) [3.60029] Parietal Lobe, Precuneus, Brodmann area 7 (0,-55,60) [3.52698] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (0,35,25) [3.51993]
26000-27000	3.552	Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (-35,-70,-20) [4.45568] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (-40,-90,0) [4.43890] Limbic Lobe, Parahippocampal Gyrus, Brodmann area 19 (-25,-55,10) [4.41734] Occipital Lobe, Inferior Occipital Gyrus, Brodmann area 18 (-40,-90,-5) [4.41615] Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (-40,-60,-20) [4.41156] Occipital Lobe, Lingual Gyrus, Brodmann area 19 (-25,-65,-5) [4.40606] Limbic Lobe, Sub-Gyral, Brodmann area 19 (-15,-45,-10) [4.27724] Temporal Lobe, Inferior Temporal Gyrus, Brodmann area 20 (-50,-50,-20) [4.27524] Limbic Lobe, Posterior Cingulate, Brodmann area 30 (-20,-60,5) [4.24921] Occipital Lobe, Cuneus, Brodmann area 18 (-25,-95,-5) [4.20582] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-5,50,35) [4.19178]	Temporal Lobe, Fusiform Gyrus, Brodmann area 37 (40,-60,-25) [4.33388] Occipital Lobe, Fusiform Gyrus, Brodmann area 19 (40,-65,-20) [4.28495] Occipital Lobe, Inferior Occipital Gyrus, Brodmann area 18 (40,-85,-15) [4.26547] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (35,-85,-15) [4.22371] Occipital Lobe, Lingual Gyrus, Brodmann area 18 (5,-90,-15) [4.10241] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (60,-55,30) [4.09505]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,40,35) [4.22828] Occipital Lobe, Lingual Gyrus, Brodmann area 18 (0,-90,-15) [4.16427]

Table XIII List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Licor Beirão 2 (Continued)

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
27000-28000	2.840	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (-30,35,40) [3.75225] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-20,40,35) [3.69265] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.68856] Frontal Lobe, Medial Frontal Gyrus, Brodmann are 6 (-5,30,40) [3.64541] Frontal Lobe, Cingulate Gyrus, Brodmann area 6 (-15,25,40) [3.58213] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-10,25,35) [3.49648] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (-15,35,25) [3.43978]	Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30,-80,45) [3.66889] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.66175] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (45,-50,55) [3.59362] Parietal Lobe, Precuneus, Brodmann area 19 (30,-85,35) [3.53105]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (0,30,45) [3.49474] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,35,50) [3.46593] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (0,25,35) [3.35327]

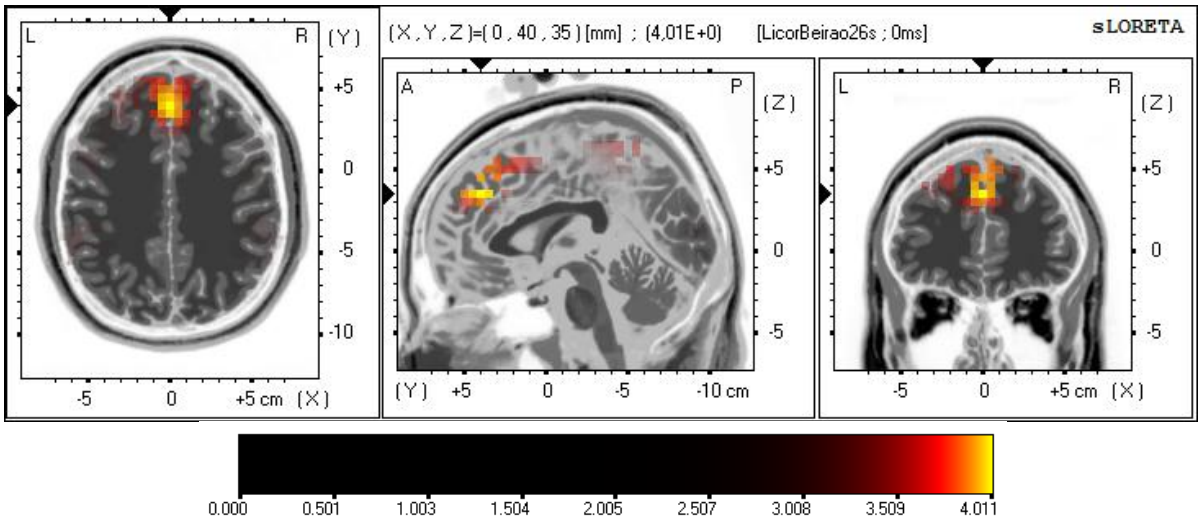

Figure 17 Slice view of the brain with the regions being activated highlighted. At the left an axial slice, at the middle a sagittal slice and at the right a coronal slice. The coordinates of the maximum activation are indicated (X,Y,Z) = (0,40,35) [mm], which is Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9.

The reason why we decided to show here only three moments of each ad was because: first, the amount of images we would have; and secondly and most important we figured out that there were three major instances for this ad (the beginning, a sudden change and the moment of the brand). However by doing the Table XIII we were able to show the same information only not visually and it using the information in the table that we are able to know more precisely what regions are being activated.

Beginning with the first second it can be seen that one of the activated regions is the Fusiform Gyrus. One of the functions of the fusiform gyrus is face and body recognition. Actually, studies show that the fusiform gyrus has a specific region that is selectively activated by faces (Kanwisher, McDermott et al. 1997). As we can see in Figure 16 A) on the first second two people appear with their faces in focus. Thus, it is understandable and reasonable to see this region being more activated. Also, BAs 18 and 19 related to visual association, to shape recognition and attention start being more activated. Again understandable since the participants were watching a video, furthermore, areas like the primary, secondary and associative visual cortex will be activated through the entire ad. It is interesting to see an activation of the Limbic Lobe and Parahippocampal Gyrus since the first second of the video. This cerebral region is responsible for encoding and recalling places (Aguirre, Detre et al. 1996). In this second two people enter into a pub, and that is why this region was activated, the participants were recalling or recognizing the space as a pub.

After the 3rd second the attention is drawn to another actor. A very characteristic Portuguese sound from bullfights can be heard as the attention is drawn to the newcomer. A representative frame of this sequence is shown in the Figure 16 B). During this second, regions of the Temporal Lobe are activated. The Temporal Lobe is involved in auditory perception. This activation can be explained by the sound heard on this sequence of the video. It can be seen that frontal regions of the brain in BAs 6, 7, 8 and 9 start being activated. BAs 8 and 9 and parietal BA 7 have been correlated to the memorization process of an ad. Prefrontal and parietal regions play an important role in coding the

information that will be remembered by the subjects from the ads (Astolfi, Fallani et al. 2008). So the sequence from this ad can be identified as a key moment for the recognition of the ad. Various studies have been researching why ads and some moments of it are more remembered (see review of studies in chapter 1.3). Again, we recall the HERA model to interpret these results. As mentioned, the model claims that one of the left prefrontal cortex functions is encoding information into episodic memory (whether this moment would be remembered afterwards requires another study and an all new paradigm that we did not explore). It can also be seen that limbic regions, particularly the cingulate cortex, are activated. The anterior cingulate cortex (ACC) is believed to interact with other brain structures as a part of the circuit responsible for cognitive and emotional processing (Bush, Luu et al. 2000), which leads us back to MAC theory and others like the somatic marker hypothesis of Damasio. Both theories brought back to economy the importance of emotions in decision-making. If in fact, emotions play a key role in decision and are so important in the process of memorization, and because the results show activity in structures responsible for emotional processing (like the VMPFC as claimed in Damasio hypothesis), and because of what has been said until now, we can allege that this moment will be memorable and probably important in the recognition of the ad. Moreover, we can make inferences about the effectiveness of this ad, because studies have shown that attractive ads lead to a stronger activation in the VMPC that is important in the integration of emotions in the decision-making process, and in the nucleus accumbens (reward stimulus) (Kenning and Plassmann 2008).

At last, we are interested in viewing what happens when the logo of the brand or the product appears, represented in Figure 16 C). The logo of Licor Beirão does not appear alone, it appears on a bottle (Licor Beirão is a Portuguese liquor) and it starts coming into sight at the second 22, being clearly visible after the second 23. The regions being activated can also be seen in Figure 17. It is interesting to see that regions of the cingulate cortex are being activated during these moments of the ad. The cingulate cortex i part of the limbic lobe and is involved in emotion formation and processing. Santos (2008) also reported in his work the activation of the Paracingulate Cortex when viewing brand logos, establishing a correlation with the Theory of Mind. The Theory of Mind is the ability to understand others as psychological beings that have mental states such as desires, beliefs, emotions, intentions, and so on (Meltzoff 1996). The medial frontal cortex (MFC) plays an important role in social cognitive processing, such as the ones explained by the Theory of Mind like self-reflection and person perception (Amodio and Frith 2006). What the results show is that in the moments where the brand appears, structures like Brodmann areas 8, 9, 10 and 32 (belonging to the MFC) are more activated. This confirms that watching brand logos triggers the same brain structures used when there is self-reflection or when making inferences about others' thoughts, which is in accordance with Santos (2008). Therefore, it can be said that brands have a social intrinsic value and that can be uses to categorize others, confirming what other studies have theorized: brand is much more than just a logo, or a name, or a colour or a shape (McClure, Li et al. 2004; Schaefer, Berens et al. 2006; Koeneke, Pedroni et al. 2008).

Next, we wanted to compare the last results with the TV commercial of Optimus. So, the same procedure done before was applied to the ad Optimus 2. As before, three moments of the adwere selected: the first second, one in the middle and one in the end were the brand appeared (see Figure 17). As before we show for the moment of the brand the regions being activated with a slice view (Figure 19).We also represented the results in Table XIV that had the same structure as before. These three moments were the ones we felt that could be key instances of the ad and at the same time were chosen to be comparable to the other three moments of Licor Beirão's ad.

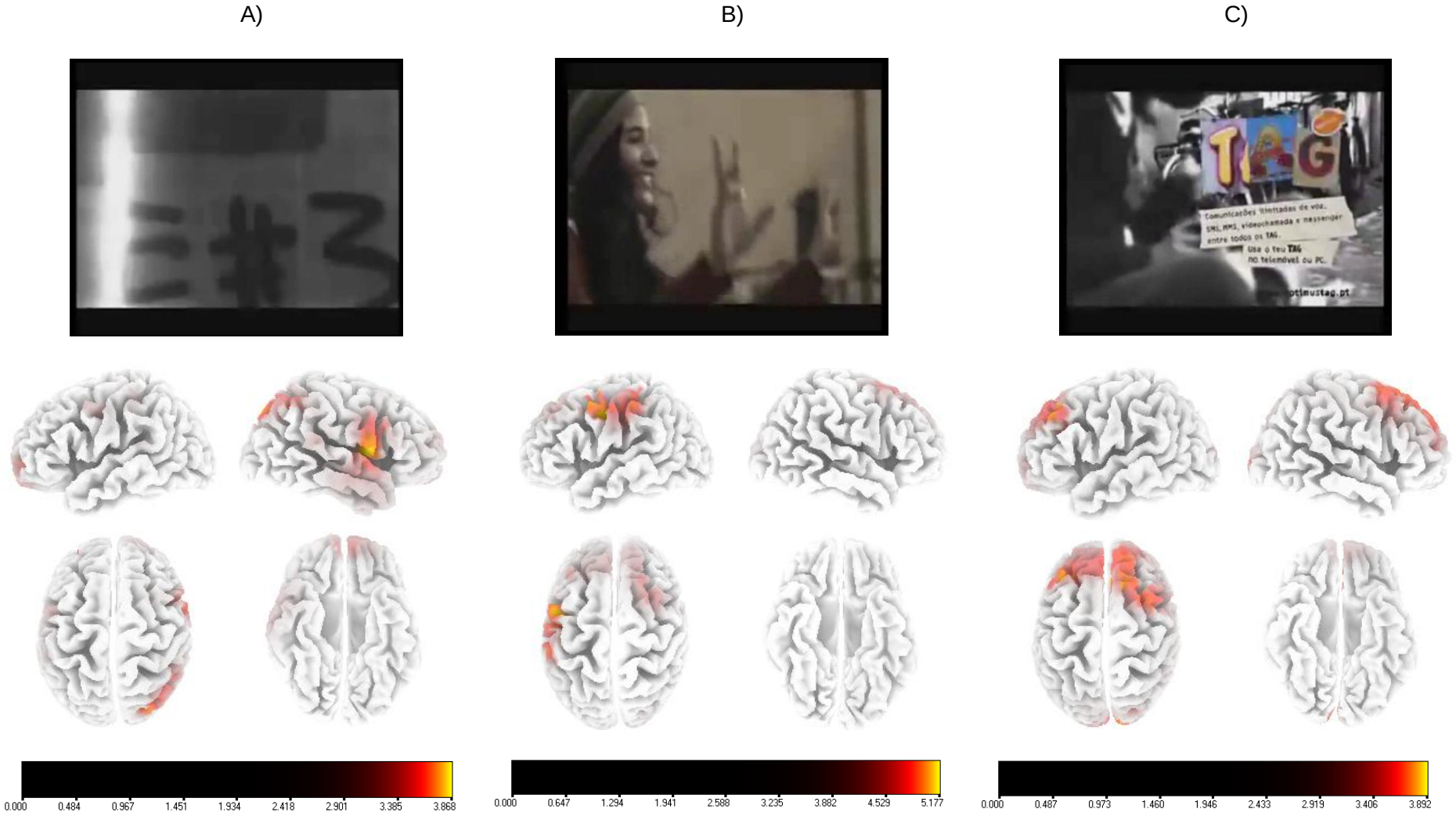

Figure 18 3D images of the cortex with the regions being more activated for the three moments. Each moment is represented by a frame. A) First second of the ad. On the top a frame take from that second and on the bottom a group of four views of the cortex (left, right, top, bottom, from the left top to the right bottom). This structure is common to the following sub-parts of the figure. B) From the 25th second to the 26th of the ad. C) From the 29th second to the 30th second of the ad.

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
0-1000	3.150	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 10 (-30,55,5) [3.57847] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 10 (-25,50,5) [3.56415]	Frontal Lobe, Inferior Frontal Gyrus, Brodmann area 44 (60,5,15) [3.86824] Frontal Lobe, Precentral Gyrus, Brodmann area 6 (60,0,10) [3.85085] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30,-80,45) [3.74024] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 22 (55,0,5) [3.72724] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.69346] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-55,50) [3.59435] Sub-lobar, Insula, Brodmann area 13 (45,-5,5) [3.54056]	-
1000-2000	3.943	Frontal Lobe, Precentral Gyrus, Brodmann area 6 (-45,5,45) [4.78233] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (-45,0,45) [4.76763] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (-50,-30,50) [4.6265] Parietal Lobe, Postcentral Gyrus, Brodmann area 2 (-55,-30,50) [4.60252] Frontal Lobe, Sub-Gyral, Brodmann area 6 (-35,-5,45) [4.04135]	Frontal Lobe, Inferior Frontal Gyrus, Brodmann area 44 (60,5,15) [4.00282] Frontal Lobe, Precentral Gyrus, Brodmann area 44 (60,5,10) [3.99690]	-

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2 (Continued).

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
2000-3000	2.773	Frontal Lobe, Precentral Gyrus, Brodmann area 6 (-50, 5,45) [3.61211] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (-45,0,45) [3.61100] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (45,-50,50) [3.44982] Parietal Lobe, Postcentral Gyrus, Brodmann area 2 (-50,-30,55) [3.43916] Frontal Lobe, Inferior Frontal Gyrus, Brodmann area 6 (-45,0,35) [3.20085] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 11 (-5,55,-15) [3.19577] Limbic Lobe, Anterior Cingulate, Brodmann area 10 (-10,50,0) [3.07930] Frontal Lobe, Orbital Gyrus, Brodmann area 11 (-5,50,-20) [3.06173]	Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (45,-55,55) [3.43168] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30,-80,45) [3.42393] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (30,10,65) [3.39256] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.36493] Frontal Lobe, Rectal Gyrus, Brodmann area 11 (5,55,-25) [3.23080] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (35,15,55) [3.21328] Parietal Lobe, Precuneus, Brodmann area 7 (25,-75,40) [3.18333] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 11 (5,60,-15) [3.11905] Frontal Lobe, Sub-Gyral, Brodmann area 6 (25,0,60) [3.10406] Frontal Lobe, Orbital Gyrus, Brodmann area 11 (5,50,-20) [3.06595] Occipital Lobe, Cuneus, Brodmann area 18 (10,-100,15) [3.01436] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (10,-100,10) [3.01222] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (20,5,50) [2.97988]	Occipital Lobe, Cuneus, Brodmann area 18 (0,-100,5) [2.79423]

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2 (Continued).

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
3000-4000	2.626	Parietal Lobe, Precuneus, Brodmann area 31 (-20,-45,35) [3.42536] Limbic Lobe, Sub-Gyral, Brodmann area 31 (-20,-50,35) [3.41449] Limbic Lobe, Cingulate Gyrus, Brodmann area 31 (-15,-45,35) [3.37065] Parietal Lobe, Sub-Gyral, Brodmann area 40 (-35,-45,35) [3.27366] Sub-lobar, Insula, Brodmann area 13 (-40,-45,20) [3.26056] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 10 (-25,50,5) [3.17652] Frontal Lobe, Paracentral Lobule, Brodmann area 5 (-15,-40,50) [3.13913] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 39 (-35,-55,25) [3.13128] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 8 (-35,30,45) [3.12322] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (-40,-45,35) [3.07296] Temporal Lobe, Sub-Gyral, Brodmann area 39 (-30,-60,25) [3.05154]	Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30,-80,45) [3.59868] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-50,50) [3.57923] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.55174] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (25,10,65) [3.22702] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 6 (20,15,65) [3.12742] Parietal Lobe, Angular Gyrus, Brodmann area 39 (35,-65,35) [3.11538] Frontal Lobe, Medial, Frontal Gyrus, Brodmann area 9 (15,35,35) [3.11344] Frontal Lobe, Rectal Gyrus, Brodmann area 11 (5,55,-25) [3.10794] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (15,-100,10) [3.06484] Occipital Lobe, Cuneus, Brodmann area 18 (15,-100,15) [3.05747]	-
4000-5000	2.528	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (-30,30,40) [3.28986] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.24453] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (-25,40,45) [3.21886] Frontal lobe, Cingulate Gyrus, Brodmann area 6 (-15,25,40) [3.13494] Limbic Lobe, Cingulate Gyrus, Bordmann area 32 (-10,25,35) [3.10753]	Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30,-80,45) [3.55627] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.55051] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-50,50) [3.38836] Occipital Lobe, Cuneus, Brodmann area 19 (25,-85.30) [3.16138] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (45,25,35) [3.09946] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 10 (25,45,25) [3.08821] Frontal Lobe, Rectal Gyrus, Brodmann area 11 (5,55,-25) [3.03041] Parietal lobe, Angular Gyrus, Brodmann area 39 (45,-75,35) [3.01644] Sub-lobar, Insula, Brodmann area 13 (55,-35,20) [3.02535]	-

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2 (Continued).

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
25000-26000	4.223	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (-45,0,45) [5.17657] Frontal Lobe, Precentral Gyrus, Brodmann area 6 (-45,-5,45) [5.16056] Parietal Lobe, Postcentral Gyrus, Brodmann area 2 (-55,-30,50) [4.95263] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (-50,-30,50) [4.95230] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [4.44328] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (-5,40,45) [4.43998] Frontal Lobe, Cingulate Gyrus, Brodmann area 6 (-15,25,40) [4.33650] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-10,25,35) [4.25358]	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 6 (30,10,65) [4.65603] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 6 (20,25,60) [4.63266] Occipital Lobe, Cuneus, Brodmann area 18 (15,-100,15) [4.32378]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (0,40,45) [4.41238] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,35,50) [4.38529]
26000-27000	2.687	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 8 (-35,30,45) [3.60498] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.49052] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-20,40,35) [3.43900] Frontal Lobe, Precentral Gyrus, Brodmann area 9 (-40,25,40) [3.41182] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (-15,35,30) [3.39083] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (-15,35,25) [3.31053]	Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (40,-55,50) [3.84529] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (40,60,55) [3.82901] Parietal Lobe, Precuneus, Brodmann area 19 (40,-75,45) [3.66810] Frontal Lobe, Rectal Gyrus, Brodmann are 11 (5,55,-25) [3.40693] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 11 (5,60,-20) [3.39049] Parietal Lobe, Angular Gyrus, Brodmann area 39 (45,-75,35) [3.37676] Occipital Lobe, Cuneus, Brodmann area 18 (15,-100,15) [3.34878] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (15,-100,10) [3.30121] Frontal Lobe, Orbital Gyrus, Brodmann area 11 (10,55,-25) [3.26479] Temporal Lobe, Angular Gyrus, Brodmann area 39 (50,-75,30) [3.22729]	-

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2 (Continued).

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
27000-28000	2.840	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (-30,35,40) [3.75225] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-20,40,35) [3.69265] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.68865] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (-5,30,40) [3.64541] Frontal Lobe, Cingulate Gyrus, Brodmann area 6 (-15,25,40) [3.58213] Limbic Lobe, Cingulate Gyrus, Brodmann area 32)-10,25,35) [3.49648] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (-15,35,25) [3.43978]	Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (30-80,45) [3.66889] Parietal Lobe, Precuneus, Brodmann area 19 (30,-80,40) [3.66175] Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (45,-50,55) [3.59362] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 19 (30,-95,10) [3.37443] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 6 (5,35,40) [3.34168]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (0,30,45) [3.49474] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,35,50) [3.46593]
28000-29000	2.879	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (.25,35,40) [3.44494] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 8 (-15,30,45) [3.40561] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.39812] Frontal Lobe, Superior Frontal gyrus, Brodmann area 9 (-20,40,40) [3.38306] Frontal Lobe, Cingulate Gyrus, Brodmann area 6 (-15,25,40) [3.37220]	Parietal Lobe, Inferior Parietal Lobule, Brodmann area 40 (45,-60,55) [3.99639] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (40,-65,50) [3.98721] Parietal Lobe, Precuneus, Brodmann area 19 (40,-75,45) [3.89315] Parietal Lobe, Angular Gyrus, Brodmann area 39 (50,-70,35) [3.61510] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 10 (20,55,30) [3.52549] Occipital Lobe, Cuneus, Brodmann area 18 (15,-100,15) [3.48664] Frontal Lobe, Middle Frontal Gyrus, Brodmann area 10 (25,55,25) [3.48500] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (15,40,30) [3.47645] Temporal Lobe, Superior Temporal Gyrus, Brodmann area 22 (65,-45,20) [3.42637] Temporal Lobe, Angular Gyrus, Brodmann area39 (50,-75,30) [3.41845] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (10,-100,10) [3.40565] Parietal Lobe, Supramarginal Gyrus, Brodmann area 40 (55,-60,30) [3.40116] Sub-lobar, Insula, Brodmann area 13 (55,-40,20) [3.36587]	-

Table XIV List of the brain regions being more activated for the specified time segmented, divided into left and right hemispheres and medial areas ($p < 0.05$), for the ad Optimus2 (Continued).

Time segment [ms]	t-threshold	Activation in left hemisphere cerebral region Brodmann areas (xyz coordinates) [t-value]	Activation in right hemisphere cerebral region Brodmann areas (xyz-coordinates) [t-value]	Activation in medial areas cerebral region Brodmann areas (xyz-coordinates) [t-value]
29000-30000	3.091	Frontal Lobe, Middle Frontal Gyrus, Brodmann area 9 (-35,30,40) [3.81552] Frontal Lobe, Medial Frontal Gyrus, Brodmann area 6 (-5,35,40) [3.77393] Frontal Lobe, Sub-Gyral, Brodmann area 9 (-25,30,35) [3.71853] Frontal Lobe, Precentral Gyrus, Brodmann area 9 (-40,25,40) [3.66462] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (-20,40,35) [3.66373] Frontal Lobe, Cingulate Gyrus, Brodmann area 32 (-5,25,40) [3.55200] Limbic Lobe, Anterior Cingulate, Brodmann area 32 (-15,35,25) [3.54079] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (-10,30,30) [3.49141] Occipital Lobe, Cuneus, Brodmann are 18 (-10,-100,15) [3.40486] Frontal Lobe, Rectal Gyrus, Brodmann area 11 (-5,55,-25) [3.31808]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (15,35,35) [3.89232] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 9 (15,25,60) [3.77697] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (10,30,35) [3.77689] Occipital Lobe, Middle Occipital Gyrus, Brodmann area 18 (15,-100,10) [3.77518] Occipital Lobe, Cuneus, Brodmann area 18 (15,-100,15) [3.74558] Frontal Lobe, Sub-Gyral, Brodmann area 8 (15,25,45) [3.70137] Frontal Lobe, Cingulate Gyrus, Brodmann area 6 (15,25,40) [3.64670] Parietal Lobe, Superior Parietal Lobule, Brodmann area 7 (25,-80,45) [3.43570] Parietal Lobe, Precuneus, Brodmann area 19 (25,-80,40) [3.43430] Frontal Lobe, Precentral Gyrus, Brodmann area 9 (40,15,40) [3.38682] Frontal Lobe, Rectal Gyrus, Brodmann area 11 (5,55,-25) [3.33035] Sub-lobar, Insula, Brodmann area 13 (35,20,15) [3.22268]	Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9 (0,35,35) [3.74064] Frontal Lobe, Superior Frontal Gyrus, Brodmann area 8 (0,35,50) [3.63911] Occipital Lobe, Cuneus, Brodmann area 18 (0,-100,5) [3.45733] Limbic Lobe, Cingulate Gyrus, Brodmann area 32 (0,25,35) [3.42789] Parietal Lobe, Precuneus, Brodmann area 7 (0,-80,45) [3.16412]

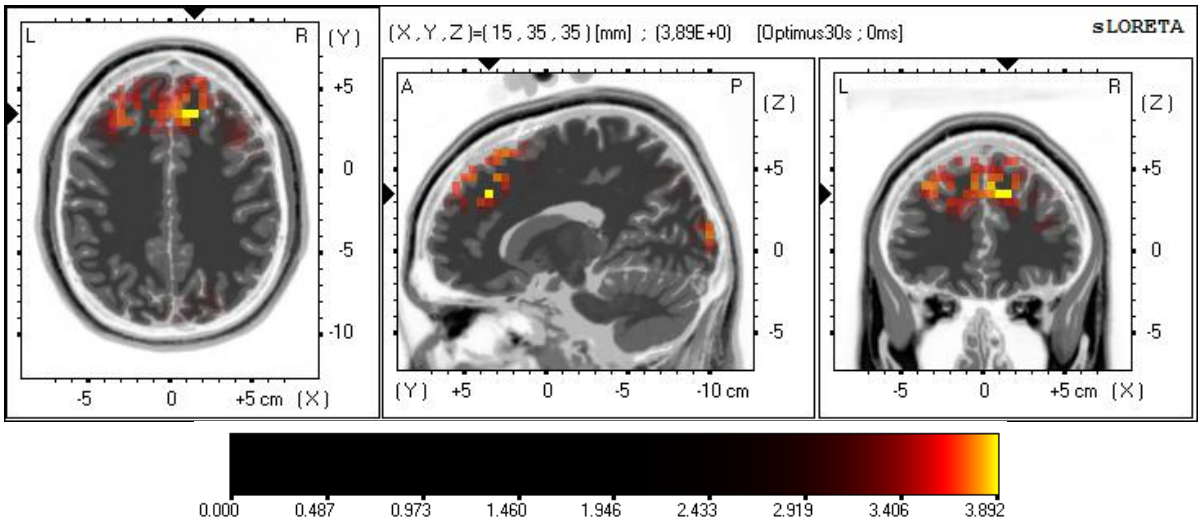

Figure 19 Slice view of the brain with the regions being activated highlighted. At the left an axial slice, at the middle a sagittal slice and at the right a coronal slice. The coordinates of the maximum activation are indicated (X,Y,Z) = (15,35,35) [mm], which is the Frontal Lobe, Medial Frontal Gyrus, Brodmann area 9.

By analysing the first second of the Optimus ad (Figure 18 A), it can be seen that fewer regions are being relatively activated (remember that these are activations compared to the inter-stimulus) than in the ad of Licor Beirão. The Temporal Lobe is being activated corresponding to the short high pitch noise that is heard at the beginning of the ad. It is also interesting to see that there is more activation on the right hemisphere, which could mean that there is retrieval of episodic information (HERA model). Contrasting the results for the two ads, for the video Licor Beirão 2 the Occipital Lobe is more activated, whereas for the video Optimus 2 it is more the frontal regions that are activated. A possible explanation is the poor visual stimuli that the video has during the first second.

The second instance chosen was randomly picked because we did not notice any special moment in the ad. Unlike the other ad that introduced a sudden change, in this ad there is always the same girl speaking. The second from 25 to 26 was randomly selected. However, we should also mention the brain regions being activated until this second. Parietal Lobe and Superior Frontal Lobe are the regions more activated. According to published works, cognitive content produces stronger activations in posterior parietal areas and superior prefrontal cortex, whereas affective content produces activity in orbitofrontal and retrosplenial cortex, amygdala and brainstem (Ioannides, Liu et al. 2000). So, it can be assumed that so far this ad has more cognitive content than affective. The second instance is one of the fewest moments where there is slightly more left than right hemisphere activation. Furthermore, some parts of the cingulate cortex are activated. In this second, shown in the Figure 18 B), it can be seen that the girl is happy, explaining these activations.

The last second has the appearance of the brand, as shown in Figure 18 C) and the brain regions activated can also be seen in Figure 19. There are words under the logo of the brand, and we can see that the background is not black, so there are a lot of other stimuli when the brand appears. The Occipital Lobe, from 28000 ms until 30000 ms, starts to be activated. As it is known, one of the functions of the Occipital Lobe is reading. The fact that this region only starts to be activated when the logo and the words underneath appear suggests that the participants were reading. Again, some

regions of the Cingulate Cortex are activated just like when the logo of Licor Beirão appeared. The interpretation is the same as given before. However, the regions activated for this ad are fewer than for Licor Beirão. To interpret these results we should clarify that the brand Optimus received many indifferent scores (see Figure C.8). On the other hand, Licor Beirão is a rather negative brand (see Figure C.8). When comparing positive brands with indifferent brands it has been found that the positive ones activate neural circuits responsible for emotional processing, the same as described in the somatic marker hypothesis proposed by Damasio, whereas the indifferent one did not (Santos, Brandão et al. 2007). Those results were not generalized only for “negative brands” because of the lack of statistical significance. However, in this case we found that some of those regions responsible for emotional processing are indeed activated for Licor Beirão (which was a negative brand) and are not activated for Optimus. This may be another confirmation that brands have emotional content. We are not generalizing because the logo does not appear isolated so we cannot be completely sure that this activation is not due to other stimuli. Overall, the ad of Optimus had less emotional neural circuits being activated than Licor Beirão. The only question remaining is if that led to a worse score of the ad and had an influence on the effectiveness of the ad.

4. Conclusions and Future Developments

In this chapter we will introduce the major conclusions of this work, provide useful information for future research and give insight important views on what went wrong during this work, and how to solve it, or how could have been solved. We want to stress the importance of this chapter as this work is exploratory and the field we are working on is still new and on development.

4.1 Conclusions

This work was essential in providing key tools and knowledge about fields like neuromarketing, consumer behaviour and advertising research. These tools and knowledge will be undoubtedly useful for future works. The results obtained, given the limitations that we had and the novelty of this field, are considered to be satisfactory.

The first result obtained showed that the video Licor Beirão 2 had greater theta activity in the midline and frontal cortical regions than the video Optimus 2. We concluded that this could mean more emotional content in the first ad. Both had also alpha rhythms activity in occipital regions, congruent with the fact that this rhythm is known to be originated in the occipital cortex.

Secondly, the same analysis was done for the Sagres ad, but dividing the participants into two groups: Dislike Sagres (DLS) and Like Sagres (LS). The aim was to see differences between the two groups when viewing the same ad. No differences were seen in theta rhythms, but there was more alpha activity in the occipital cortex for the DLS group. The interpretation given was that, because alpha waves means less activation of those regions, maybe that group was not so focused on the video. However, we concluded that more participants would be necessary to come up with a clearer and a more significant result.

Next we decided to do a combined analysis of the two questionnaires. This analysis is not a neuroscience approach, but we felt it necessary to better understand the results. An unpaired t-test was performed by dividing the questionnaire about the brands into three groups for each brand: Dislike the brand (DL), Indifferent (I) and Like the brand (L); and comparing the scores given by each group to an ad of that same brand. It was concluded that the participants who like the brand tend to give better scores to the ad of that brand, but some ads received better or worse scores whether they dislike it or not (e.g. Licor Beirão and Optimus, respectively). Therefore, this analysis can also show that in fact Licor Beirão ad is an effective one and Optimus ad not.

The next analyses were about asymmetries in the brain, using alpha, theta and beta bands. First, were studied alpha power asymmetries for the ads of Licor Beirão and Optimus. The results here were not conclusive. The asymmetries that other studies found were not perceived here. However, another study from Davidson et al. (1990) obtained the same results, concluding that analysing the whole video would not work. This makes sense because Davidson's model says that there are asymmetries for approach/withdrawal related reactions, but if you analyse all the video at once you will be mixing all the possible reactions of all the instances of the ad, thus cancelling asymmetries. For the same ads we analysed next the theta and beta power dominance for the entire brain cortex. The results show

that Licor Beirão had more theta and beta power. This result was pretty satisfactory. In this case we were not looking for asymmetries but for dominances of specific wave rhythms. We concluded that the video of Licor Beirão had more emotional (affective) content, because of theta waves, and that participants were more focused and alert to this video, because of beta waves. In general it can be said that this video provokes an approach-related reaction when compared with the ad of Optimus.

Again the same procedure was performed for the two groups of the brand Sagres. The results for the alpha band were again inconclusive. Although, in the study of the brand Sagres the results were not conclusive, it would be interesting to further explore this issue. Further study of the differences between the group that dislikes a brand and the one that likes the brand, when watching a commercial is necessary and interesting. Using just a frequency analysis some differences were observed showing that it is promising to continue. As it was said, one of the reasons a significant result did not appear may be due to the small group of people (only four for each group). Future research with more participants, with focus on one brand and showing just one commercial of that brand is necessary, and the use of LORETA could be also useful as it was proven to be helpful in our research.

The last analysis used the software sLORETA for the identification of brain structures that were activated. The results showed that there was a possible key moment in the ad of Licor Beirão, that might be more recognized. In general the ad Licor Beirão 2 had more activation in sites like the prefrontal region and cingulate cortex, confirming that indeed Licor Beirão's ad had more emotional content. The ad of Optimus did not have so many limbic regions being activated, but rather the Parietal Lobe was more activated indicating that the video was more cognitive. To infer about the recall of the ad, and establish a correlation with the higher emotional or cognitive content further studies are necessary using another paradigm that includes a posterior questionnaire.

We also analyse the moments when the brand's logo appeared. Interestingly, some regions activated were the same as in the study of Santos (2008) that used only images of logos and divided into three groups: positive, negative and indifferent. It was concluded that, although the results were similar, we cannot separate the logo from the context of the ad, thus is not completely sure what provoked those similarities. The last sentence is to suggest further studies, to continue the work. We have found that there was an ad that had better scores and had more emotional processing neural circuits activated, and that there was an ad that had worse scores and less emotional processing neural circuits activated. Now it is necessary to explore if the ad that better scored was more effective in the long-term and if that effectiveness is due to more emotional content.

4.2 Issues and suggestions

Throughout this work some issues were encountered that had to be overcome. We feel the need to mention them here to show what type of problems can happen during a study like this. This work could still be perfected and we are sure that with future works, the initiated research began here will be perfected. We also feel that with the means at our disposal this study was the possible one to do.

The time was undoubtedly the biggest problem. What one should have in mind when starting experiments like this is that they demand a lot of time. You need to prepare the experiment, you need to prepare the laboratory, you need to find people to be your participants, you need them to have time to do all your experiments, and then, if anything goes wrong (for example, you realize that the procedure is not adequate), you need time to re-do everything.

Then you have the equipment issue. In this study the equipments used were very expensive, and at the beginning of it, they were not yet purchased. Also important to mention was the lack of time to do pre-tests. Pre-tests are essential to better chose the stimuli to present, the best way to present them and to see if the paradigm is working and yielding or not the desirable results. Other research give an enormous importance to pre-test to choose the best TV commercials that would suit the purposes of the work, and it is in the pre-tests that they do most of the questionnaires (see the review of studies in neuromarketing in section 1.3).

The space question was another problem. Where to assemble the laboratory? How to arrange the space inside the room? The experiment took place in a room of the Centro de Electroencefalografia e Neurofisiologia Clínica. Arrangements to the place had be made so it could be possible to conduct the experiments. The room was not ideal at the start, as the participant would not be completely isolated, nor had the room a good sound isolation. However, in the end it became very satisfactory.

We have mentioned before the issue with the equipment, particularly with the EEG, but more equipment was necessary. The computer where the visualization would take place, a special keyboard had to be built, and the software for the presentation of the stimuli had also to be obtained.

The previous issues can fit in a category "*before experiment*". However, other problems appeared during the experiment that can be categorized into issues "*during the experiment*". One was with the use of the VEOG and HEOG electrodes. Because we still had little experience with the placement of the electrodes, there was one time when the HEOG electrode fell during the experiment. Afterwards, we always used some tape to place the electrodes. Continuing with these electrodes in the beginning we had some problems stabilizing the signal, and with practice we began to place them better.

Still concerning the placement of electrodes, we can also mention the difficulty we had at the beginning in decreasing the impedance of the electrodes of the cap and of the earlobes. The ones from the earlobe were specially at all experiences very hard to decrease the impedance, but the ones from the cap with time and practice less time was required in the preparation.

Another problem that occurred during the experiment were the noises that come from outside the room. Even though a signal on the door was placed explaining that an experiment was happening, the fact is that the experiment took place on a clinic and noise from patients would be inevitable. However, when speaking with the participants afterwards, we concluded that the noise was not a distracting factor.

One last difficulty was working with the software E-Prime. For some reason we do not know, the software stopped before finishing the experiment. There was one case where this happened, having to restart the experiment. Also there was once that the time of the inter-stimulus was shortened. We believe again that it was because of the software.

Finally there were the difficulties that were perceived after the experiment. For example, nomenclature for the electrode locations that the software LORETA and that we thought we were using was not the same that the system was using in the software of the BrainProducts. Some names of the electrodes were different and the software of LORETA was not recognizing them. Thankfully the solution was just a question of changing the setup in the Analyser to change the names of some electrodes and there was no need for the repeat of the experiment.

Beside the mentioned issue, the difficulties that we felt after the experiment, or during the analysis, were the common ones, like knowing how to work with specific software, knowing how to interpret our results, and to get to the desirable results.

4.3 Guidelines for future studies

Because this study was exploratory, only in the end when analyzing the results did we realize that the procedures could be done differently. This section was created so that future academic researchers can prepare their experiments better, focalizing on what their goals are. Guidelines will be given to apply from the beginning of an experiment until its end, providing at the same time some practical examples. We will also focus on the analyses we did during this work and how they can be further explored.

Starting with the preparation of a study, one should have in mind that neuromarketing, consumer neuroscience or neuroeconomics still needs development. Some of the existing studies raise doubts in the academic community. Issues with validity and reliability of those studies still endure. Lack of general theories on neuromarketing jeopardizes its growth. So when choosing the aims of your study, you should do first a bibliographic search of what was been done, make a list of the aims that those studies propose to achieve, search for critics to those same studies, and always have a critical spirit about the validity and reliability of those researches and their procedures. Note that this is an important step of your study, and with no doubt will consume a lot of your time.

After having the theory it is important to "*separate the wheat from the chaff*", and choose what is really important and decide what will be your aim. Do not try to have many aims, and have in mind that those aims will probably constraint what your procedure will come to be. After choosing the aim, prepare well your experiment. Decide what type of neuroscience tool and analysis you are going to use. Then it is of the utmost importance to do pre-tests. It is with the pre-tests that your paradigm will be perfected. You will also gain more ability and make fewer mistakes later. After this phase, you will have your final paradigm, your final stimuli will be chosen and you will have a better view of what you want to obtain. So now you will be ready to begin the "real" experiments. Try to get as many participants as possible, as higher the number higher the possibilities of obtaining a significant statistical result. Furthermore,

try to restrict the characteristics of your participants, obtaining a homogenous group (for example, use only men or only women and right-handed, or use only participants that have a specific disease). In the experiment make sure you use enough detailed questionnaires. Questionnaires can be used not only to make correlations between traditional methods used in marketing research, but they can also give you additional information that during the analysis can decrease the variables of your work (for example, if you are using videos as stimuli and if you ask if the participant liked or disliked the video you can after divide the videos into two groups, but if you also ask what emotions those videos aroused you can also divide into positive or negative films).

Next we will mention some analyses that were done and enlighten how you should structure your paradigm according to the type of analyses chosen.

4.3.1 Asymmetries

One of the oldest analyses is the study of asymmetries in EEG. There are already developments in this area, where Davidson model and HERA model are the most important improvements in explaining asymmetries. Both models were already explained so only shortly explaining: the Davidson model tries to explain the valence of emotional processing with frontal asymmetries, proposing that the left frontal cortex is involved in approach behaviours and the left with withdrawal behaviours. So depending on the emotions aroused by a stimulus, different hemispheres can be activated. Using this analysis, questions or objectives to be tested would be, for example:

- if emotive ads are more recognized and more memorable;
- confirming the MAC theory, which claims that memory and affect are more important in decision-making than cognition;
- if ads that are more emotive are more effective and do influence a consumer's behaviour.

For example, the study of Ohme, reykowska et al. (2010) that proposed to study asymmetries in TV commercials had the following procedure: selection of 3 TV ads from the same product, and divided them into 2 main parts (an emotional and an informative part); show them among other 30 distracters ads to 45 participants; the participants had all been planning to buy the type of product shown on the 3 ads; in the end of the experiment the participants were interviewed and debriefed; the analysis consisted on the average of the alpha power in the left and right frontal electrodes and comparison of the left brain activity dominance between the three ads and their parts.

Just note the differences from the procedure used in this work. In this study we only had an inter-stimulus of 6 seconds, and the experiment was already of 20 minutes in total, which for some participants was already considered to be long, in Ohme's study the inter-stimulus was of 20 seconds. The amount of participants that they had was bigger than ours, and they assembled this group that had a particular interest on the product that they studied.

Although the present study has come up with some results that could be interpreted with Davidson's model, we feel that there were lacks on its paradigm. One thing you should keep in mind if you are trying to test the hypotheses above is to make sure that the stimulus raises an emotion on the

participants (the use of facial EMG and questionnaires would be enough). Also, if you are trying to infer about the effectiveness of an ad you should make a follow up study with the same subjects a few weeks later asking which ad they remembered, which frames, or even asking again to score the same brands and see if there were any differences.

4.3.2 LORETA

Using EEG to localize brain structures being activated is one major advance in neuroscience. We are combining the exceptional temporal resolution of EEG with a better spatial resolution. This is the future of neuromarketing and it is necessary. fMRI can only give spatial resolution, which when analyzing videos is rather insufficient, and EEG until now only brought information with temporal resolution. So we feel that using LORETA, or if possible combining a better temporal resolution technique (EEG) with a better spatial resolution technique (fMRI), is extreme useful for future researches. Again, some examples of what questions or goals to be tested will be presented:

- identify branding moments;
- test if emotional moments are more memorable;
- test models like: Davidson's model, HERA model or the somatic marker hypothesis;
- show what happens when the brand's logo appear on the ad.

These are just some objectives that you could test with this analysis. Starting with identification of branding moments it is necessary to clarify first what are those moments:

"*those special, ownable moments when a brand's positioning is expressed in a fresh new way*" (Young 2002).

This goal can be correlated with the second one. Trying to identifying these moments by viewing what brain structures are being activated and categorize them as affective or cognitive would be the first step. Then you should have a second interview with the participants one week later and show them those same moments and ask whether they remembered or not. Our study did not made such posterior interviews, so although we had found a moment on one ad that had very affective content we cannot infer about these two objectives.

To test the models you have to categorize your stimuli. If you are using ads and what to compare them you have to be sure about what emotions those ads arouse. The use of a questionnaire, so participants can specify what emotions were, is essential. This step was lacking in our work, so testing Davidson's model without knowing exactly if there was any emotion arousal and whether it was an approach or withdrawal reaction made the analysis impossible to do.

We hope that these guidelines can help in future works, and help to improve what it is being done in advertising research.

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Appendix A

[Documento para o Participante]

Consentimento Informado

1. Título do Projecto.
Use of EEG as a Neuroscientific Approach to Advertising Research

O presente documento visa fornecer-lhe a informação básica de que depende o seu consentimento para a participação voluntária neste projecto de investigação. O presente documento é um requisito necessário para essa participação. Pede-se que o leia, coloque as suas dúvidas a quem lho apresenta e, se quiser participar, assine o documento. Leve o tempo que entender necessário para examiná-lo.

2. Descrição sucinta da natureza, objectivos e procedimentos do estudo.
Este estudo exploratório pretende reconhecer as zonas do cérebro activadas durante a visualização de vídeos, correlacionando os resultados com o que já se encontra descrito na literatura sobre as funções de diversas zonas do cérebro. Os dados experimentais a utilizar serão recolhidos de electroencefalogramas (EEG). O EEG é um método não invasivo de registo gráfico das correntes eléctricas desenvolvidas no cérebro. Existirá uma preparação, onde ser-lhe-á aplicado um gel exfoliante na cabeça e álcool para facilitar o registo (tudo isto irá ser retirado no final do EEG). Ser-lhe-á colocado uma touca que contém eléctrodos, que irão fazer esse registo. Não existem riscos conhecidos associados a esta técnica. Durante o EEG ser-lhe-á mostrado seis blocos de vídeos publicitários. Os dados recolhidos serão analisados com um software específico. O questionário realizado no início será constituído por perguntas de resposta fechada, do tipo se gosta, não gosta ou lhe é indiferente uma determinada marca, apresentados no ecrã do computador. Para garantir a confidencialidade será atribuído a cada participante um número.

Os investigadores assumem a responsabilidade pela confidencialidade de quaisquer dados recolhidos.

Dada a voluntariedade da sua participação, é-lhe possível desvincular-se a todo o tempo do presente processo de investigação, sendo que tanto a recusa inicial como o abandono subsequente não acarretam qualquer penalização ou perda de direitos.

Se subsistirem algumas dúvidas ou forem necessários esclarecimentos suplementares previamente à sua participação, poderá contactar:

Nome	Pedro Filipe de Jesus Pereira Custódio
Local	Consultório de Electroencefalografia e Neurofisiologia Clínica
Telefone	938119038
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3. Identificação completa dos Investigadores e Instituições envolvidos.
Pedro Filipe de Jesus Pereira Custódio
Instituto Superior Técnico, Faculdade de Medicina de Lisboa, Centro de Electroencefalografia e Neurofisiologia Clínica

_____
(Assinatura legível do responsável pela investigação)

(Assinatura do próprio participante, ou seu representante legal)

Sugerimos-lhe que conserve esta cópia do documento, ficando a outra cópia na posse do responsável do projecto.

[Sugestões para o Investigador]

1. O Consentimento Informado tem como base o direito de cada sujeito de investigação a decidir sobre si, sobre a sua situação, sobre os procedimentos em que participa – um direito que tem que exercer-se de modo informado, de modo a que aquele sujeito de investigação colabore na busca de soluções livres e responsabilizantes.
2. O documento que é entregue ao participante deve obrigatoriamente conter, no mínimo, três campos:
    1. a caracterização do projecto e indicação dos seus objectivos;
    2. a informação ao participante;
    3. o modo de validação do documento.
3. No campo 2, trata-se de traduzir em termos simples o que é razoável prever-se quanto à sequência de procedimentos e quanto a resultados, a duração, o incómodo e o risco que acarreta para o participante, as fases do processo e o tipo de participação esperada em cada uma, e finalmente os benefícios esperados em termos de avanço da ciência.
4. No documento há todo o interesse em manter-se a simplicidade e a brevidade, e idealmente esse documento não deverá ultrapassar a dimensão de uma página[8].
5. No entanto, especificidades do projecto, ou dos participantes, podem tornar necessário incluir no documento alguma informação adicional – devendo sempre ponderar-se se tal é absolutamente necessário, dado o contexto e dados os destinatários da informação. Entre muitos outros possíveis, podemos fornecer como exemplos dessa informação adicional:
    a) em casos especiais, por exemplo relativamente a mulheres grávidas ou em idade fértil, advertir para a possibilidade de riscos e efeitos secundários actualmente desconhecidos, e para a eventual necessidade de recurso a meios contraceptivos (especificando-os);
    b) a explicitação do que há de inovador e experimental na investigação;
    c) a indicação e explicação dos exames prévios de que dependa a admissão à participação no processo de investigação;
    d) a definição do número de participantes e do que é exigido de cada subgrupo (por exemplo, perguntando-se ao participante se consente na sua integração aleatória em grupos sujeitos a administração de placebos, prescindindo temporariamente da sujeição a terapêuticas alternativas, ou da participação noutros processos experimentais);
    e) caso haja alternativas terapêuticas à participação no projecto, a indicação expressa da não-essencialidade da sujeição à experimentação, indicando a disponibilidade de terapêuticas e fármacos em contextos não-experimentais;
    f) quando seja o caso, a indicação de que o direito de desvinculação unilateral do processo de investigação poderá ser condicionado pela necessidade de completamento de algum procedimento cuja interrupção representasse um risco adicional para o Participante ou para terceiros;
    g) a especificação dos procedimentos que salvaguardam a confidencialidade dos dados;
    h) a referência explícita ao facto de poderem ocorrer alterações relevantes no decurso do Projecto que possam influenciar a decisão de continuar, assumindo-se o compromisso de comunicá-lo imediatamente aos participantes, eventualmente requerendo deles um novo Consentimento Informado;
    i) a indicação de que o Consentimento Informado é dado exclusivamente para um único processo de investigação, não podendo ser usado, quer noutros projectos em que o participante se envolva, quer nas suas relações, como paciente, perante quaisquer prestadores de serviços de saúde;
    j) o esclarecimento de questões monetárias que possam ocorrer, e em especial, caso haja reembolso de despesas ou alguma forma de compensação: i) esclarecer que isso não altera o carácter voluntário e não impede a desvinculação do participante, devendo especificar-se que a desvinculação não implica a devolução das quantias já prestadas; ii) esclarecer que os investigadores se reservam o direito de terminar o processo antes dos prazos previstos, e que portanto o Consentimento Informado não confere o direito a reembolsos ou compensações para lá do termo do Projecto;

[8] Talvez não sejam de ignorar as sugestões de preenchimento que acompanham alguns formulários de Consentimento Informado nos EUA: 1. Words are familiar to the reader. Any scientific, medical, or legal words are defined clearly. 2. Words and terminology are consistent throughout the document. 3. Sentences are short, simple, and direct. 4. Line length is limited to 30-50 characters and spaces. 5. Paragraphs are short. Convey one idea per paragraph. 6. Verbs are in active voice (i.e., the subject is the doer of the act). 7. Personal pronouns are used to increase personal identification. 8. Each idea is clear and logically sequenced (according to audience logic). 9. Important points are highlighted. 10. Study purpose is presented early in the text. 11. Titles, subtitles, and other headers help to clarify organization of text. 12. Headers are simple and close to text. 13. Underline, bold, or boxes (rather than all caps or italics) give emphasis. 14. Layout balances white space with words and graphics. 15. Left margins are justified. Right margins are ragged. 16. Upper and lower case letters are used. 17. Style of print is easy to read. 18. Type size is at least 12 point. 19. Readability analysis is done to determine reading level (should be eighth grade or lower). 20. Avoid: Abbreviations and acronyms; Large blocks of print; Words containing more than three syllables (where possible).

k) a comunicação de que, caso seja necessário algum procedimento relativo aos efeitos da experimentação, tal procedimento será providenciado pelos investigadores;
l) quando tal se afigure provável e razoável, indicar ao participante que ele poderá retirar benefícios, no seu caso individual, dos progressos da ciência que o processo de investigação propiciará – ressalvando que esta informação não deve ser entendida como um elemento de persuasão para se obter o consentimento;
m) a indicação de que o documento de Consentimento Informado não constitui uma base para a determinação, ou limitação, da responsabilidade dos investigadores.

6. O documento deve ser redigido de forma a não se criar a impressão de que o sujeito foi induzido ou pressionado a dar o seu consentimento.
7. Devem evitar-se, no documento, todas as informações desnecessárias, e em especial todas as alusões cruéis ou deprimentes, ou quaisquer sugestões susceptíveis de alimentarem falsas esperanças junto dos seus destinatários.
8. Se o documento tiver que ser lido a quem é pedido o consentimento, requer-se a presença de uma testemunha, que não pode ser o próprio representante legal do participante; testemunha que terá que assinar também as várias cópias do documento.

Appendix B

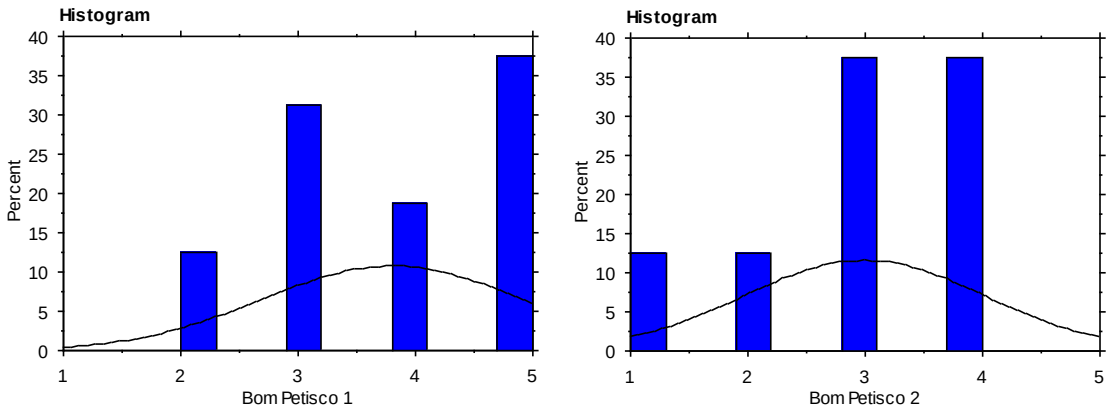

Figure B.1 Representation of the distribution of the scores given to the ads Bom Petisco 1 and Bom Petisco 2.

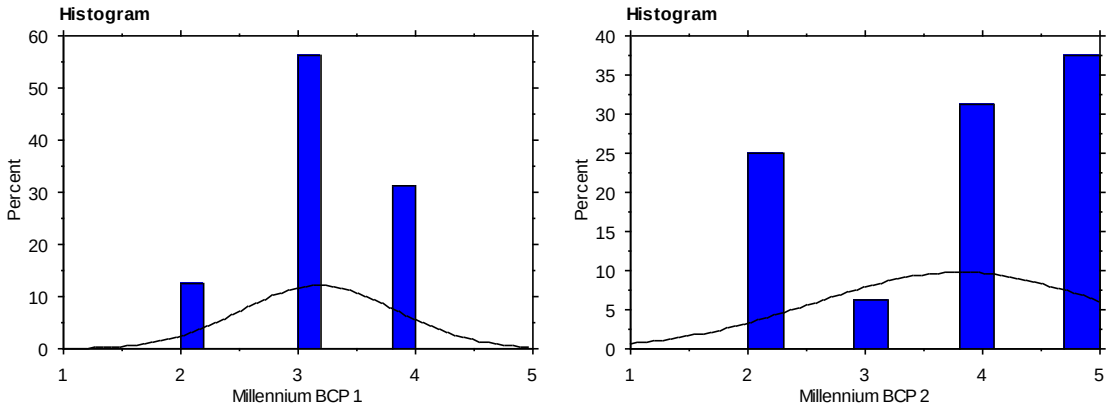

Figure B.2 Representation of the distribution of the scores given to the ads Millennium BCP 1 and Millennium BCP 2.

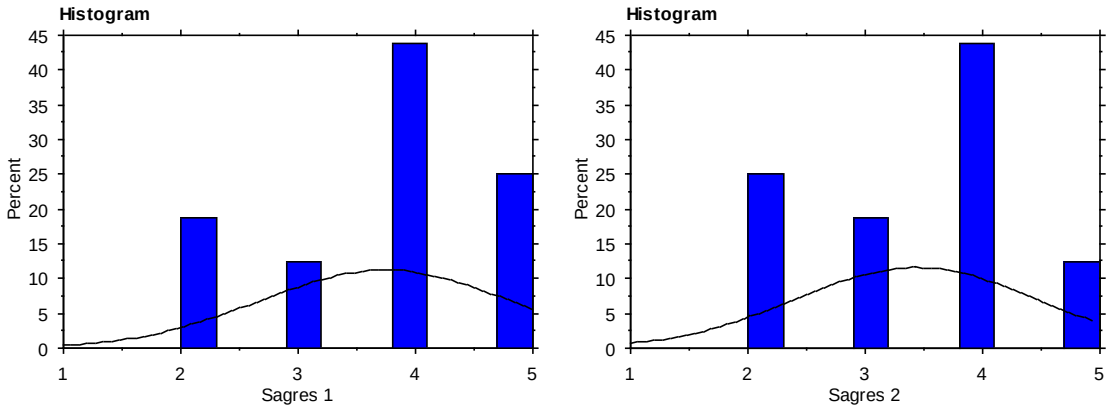

Figure B.3 Representation of the distribution of the scores given to the ads Sagres 1 and Sagres 2.

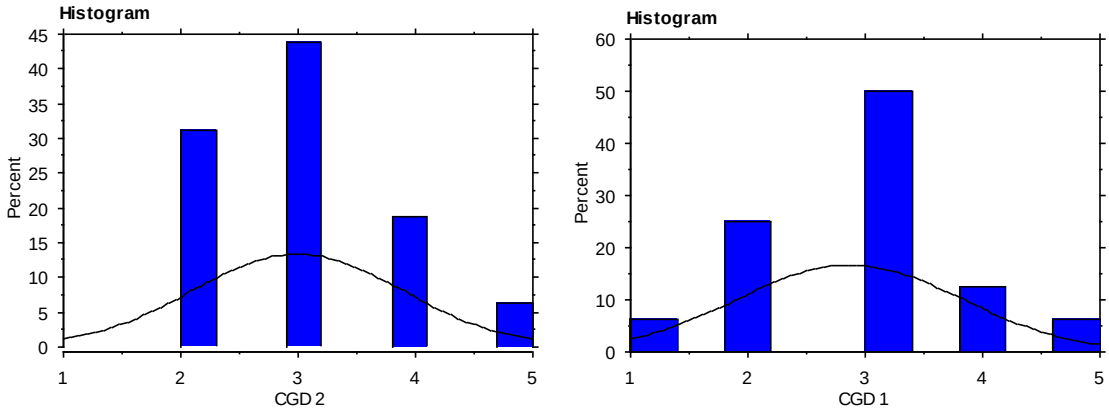

Figure B.4 Representation of the distribution of the scores given to the ads CGD 1 and CGD 2.

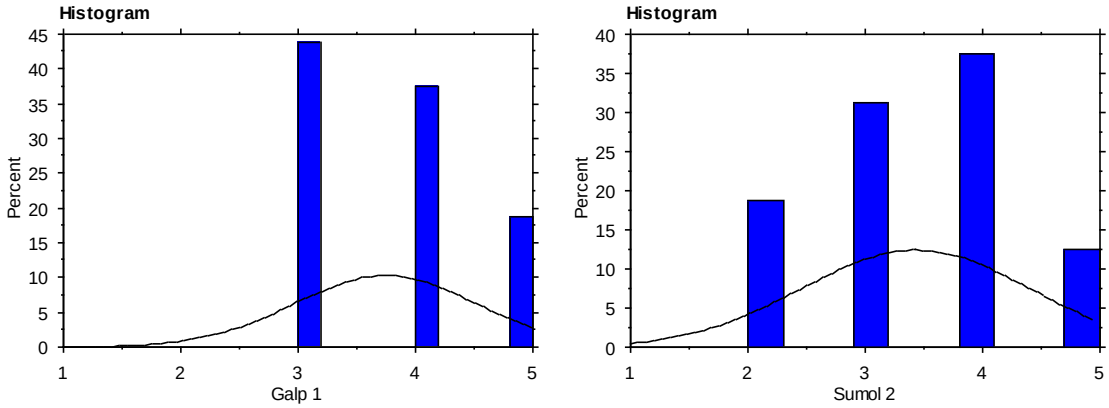

Figure B.5 Representation of the distribution of the scores given to the ads Galp 1 and Sumol 2.

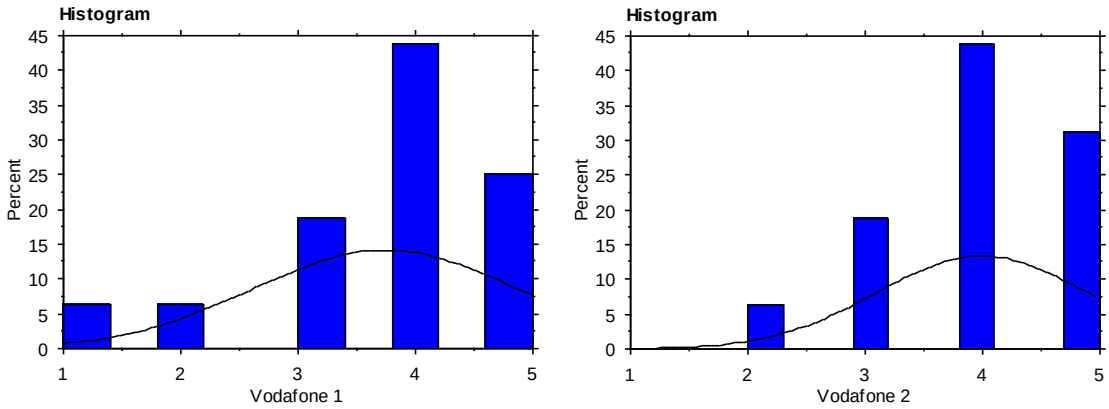

Figure B.6 Representation of the distribution of the scores given to the ads Vodafone 1 and Vodafone 2.

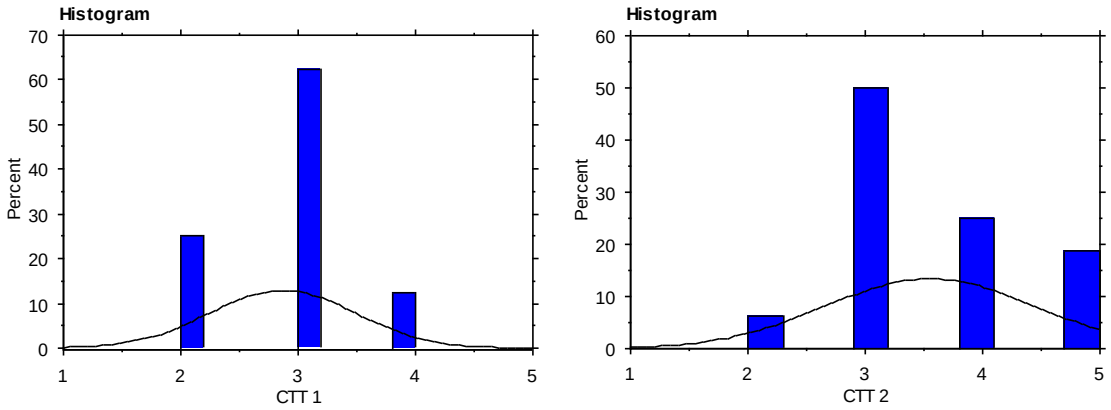

Figure B.7 Representation of the distribution of the scores given to the ads CTT 1 and CTT 2.

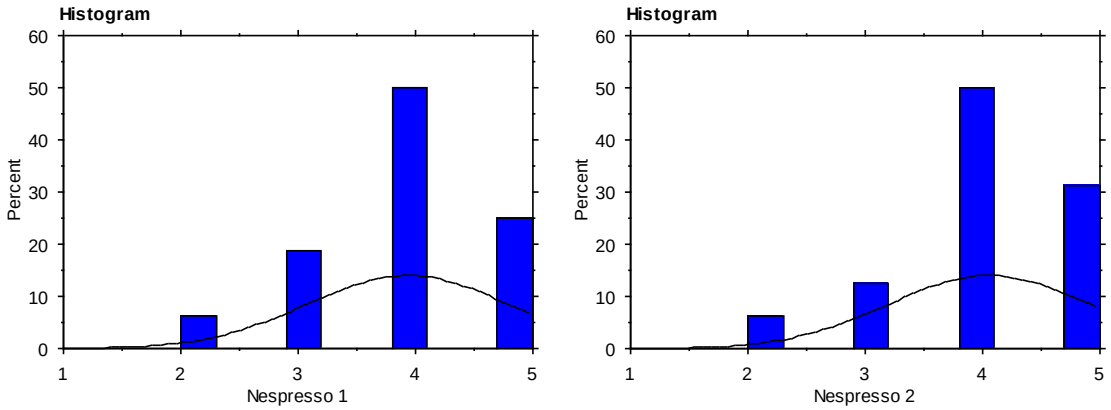

Figure B.8 Representation of the distribution of the scores given to the ads Nespresso 1 and Nespresso 2.

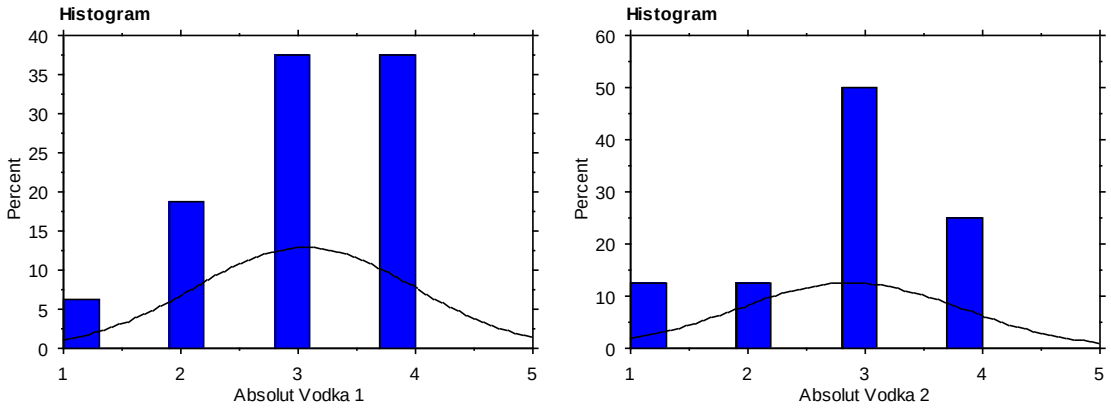

Figure B.9 Representation of the distribution of the scores given to the ads Absolut Vodka 1 and Absolut Vodka 2.

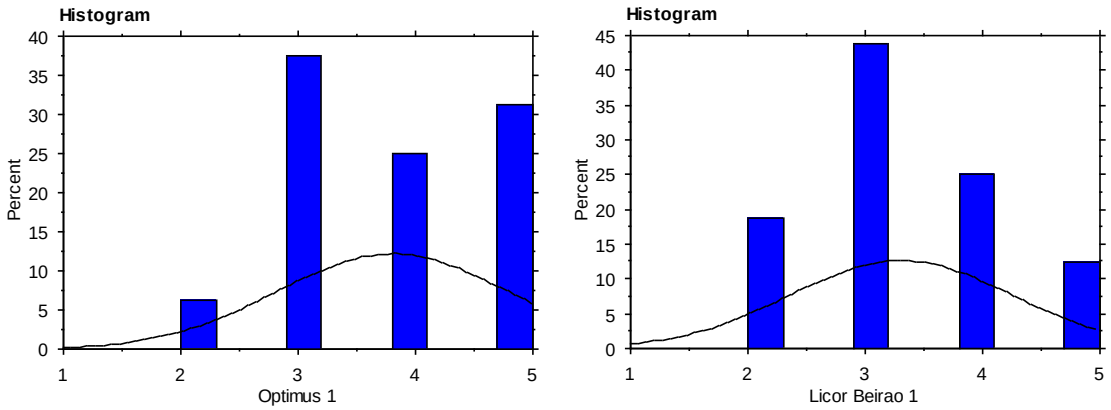

Figure B.10 Representation of the distribution of the scores given to the ads Optimus 1 and Licor Beirão 1.

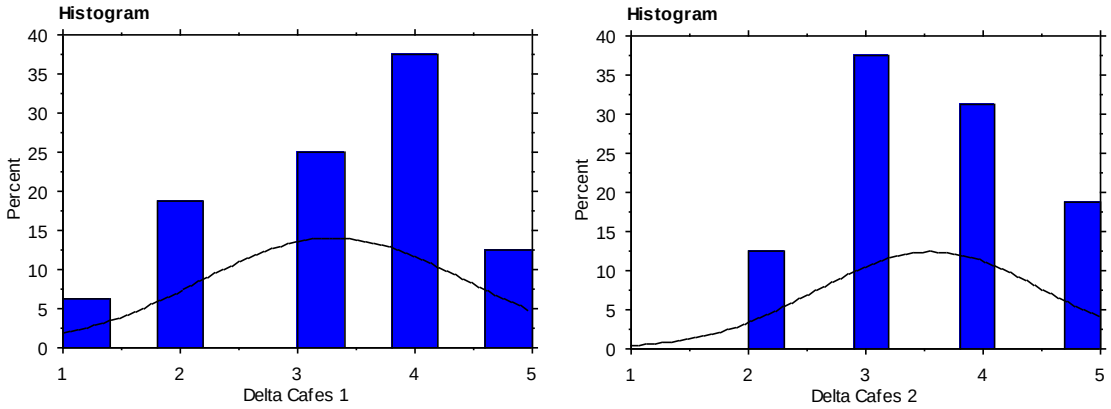

Figure B.11 Representation of the distribution of the scores given to the ads Delta Cafés 1 and Delta Cafés 2.

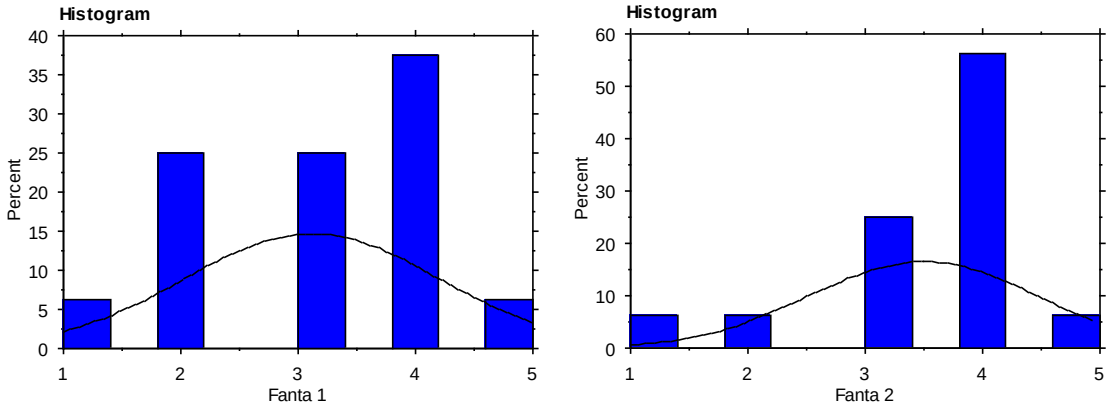

Figure B.12 Representation of the distribution of the scores given to the ads Fanta 1 and Fanta 2.

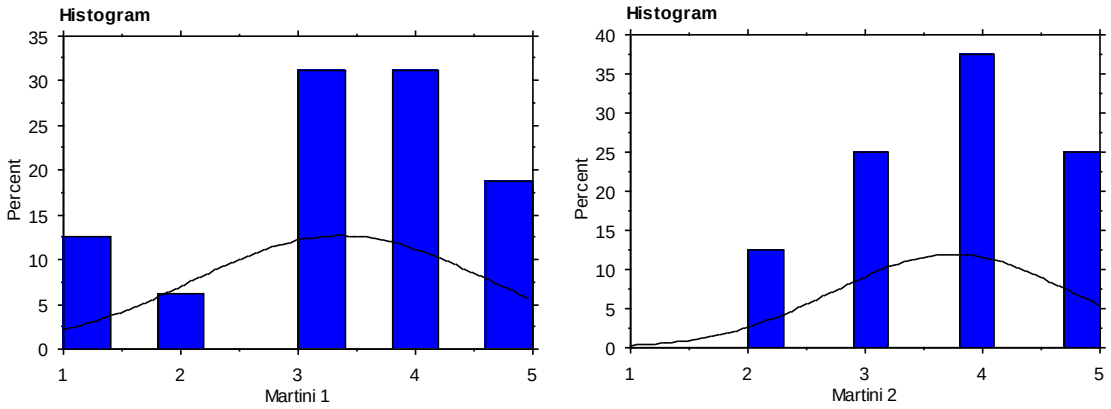

Figure B.13 Representation of the distribution of the scores given to the ads Martini 1 and Martini 2.

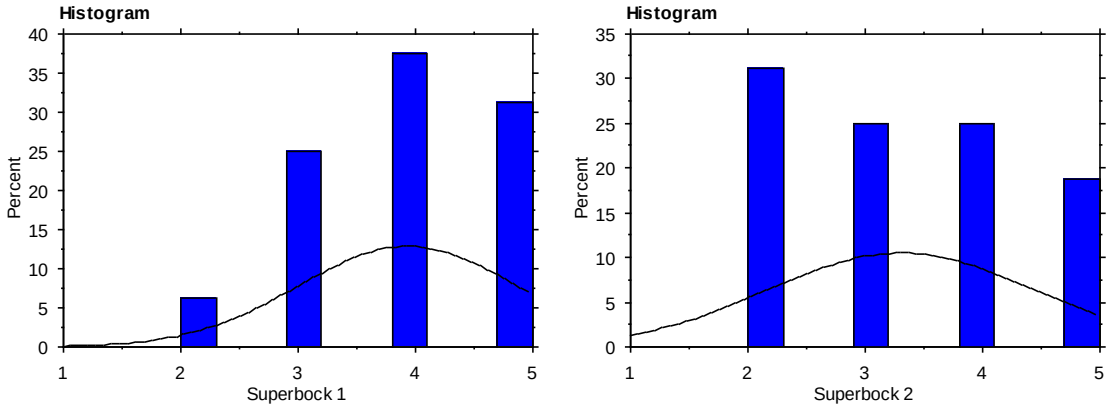

Figure B.14 Representation of the distribution of the scores given to the ads Super Bock 1 and Super Bock 2.

Appendix C

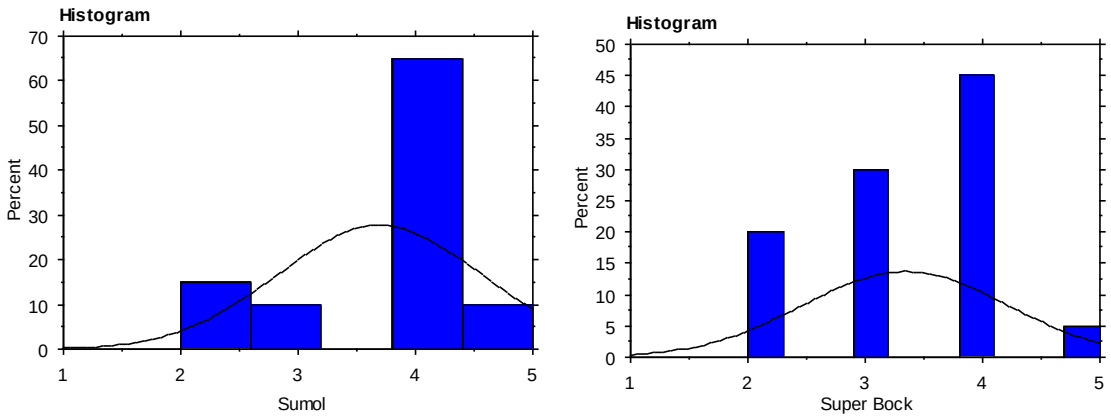

Figure C.1 Representation of the distribution of the scores given to the brands Sumol and Super Bock.

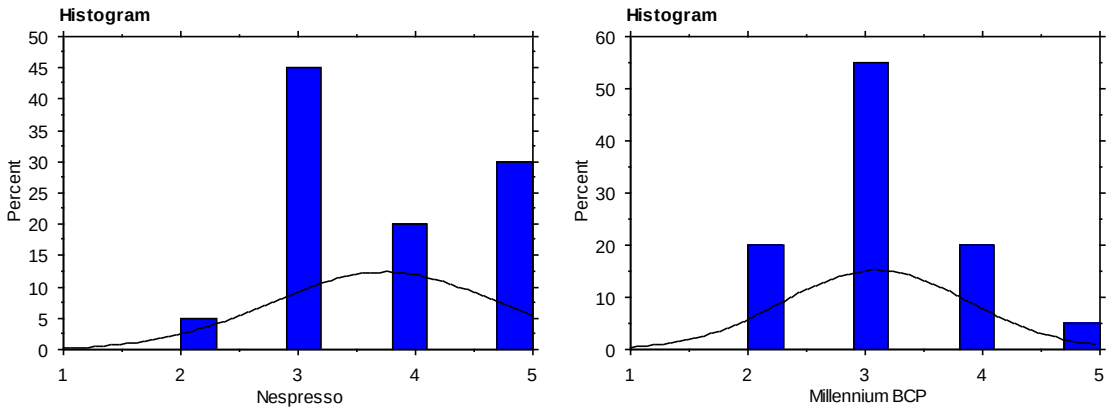

Figure C.2 Representation of the distribution of the scores given to the brands Nespresso and Millennium BCP.

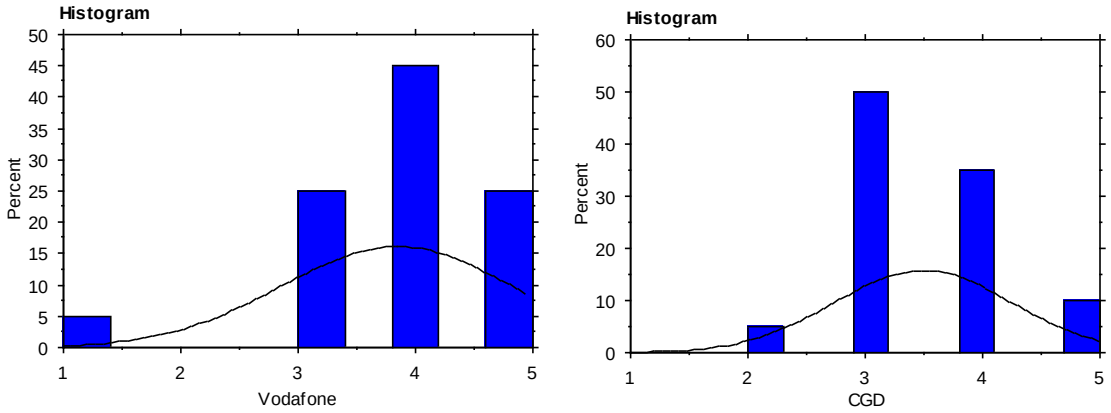

Figure C.3 Representation of the distribution of the scores given to the brands Vodafone and CGD.

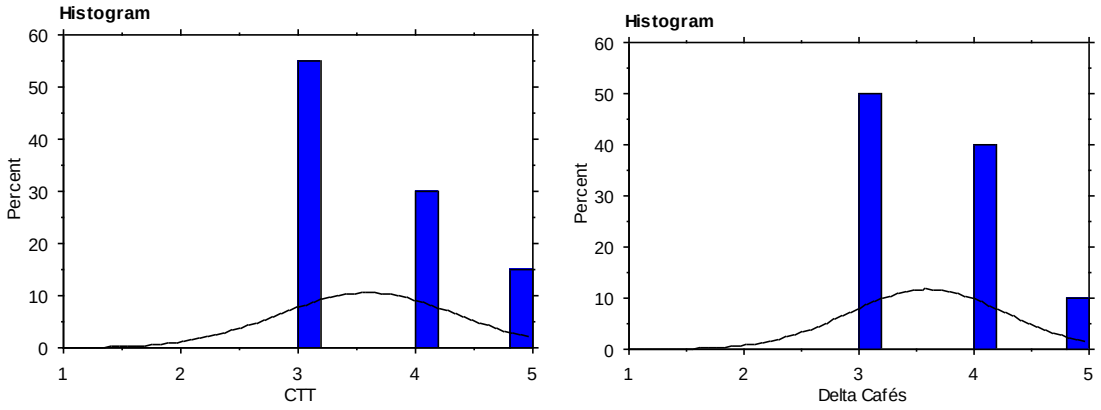

Figure C.4 Representation of the distribution of the scores given to the brands CTT and Delta Cafés.

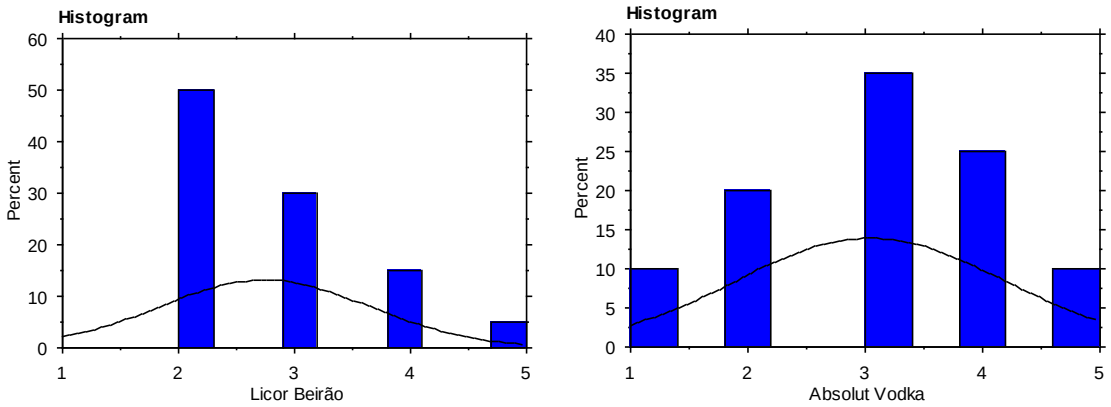

Figure C.5 Representation of the distribution of the scores given to the brands Licor Beirão and Absolut Vodka.

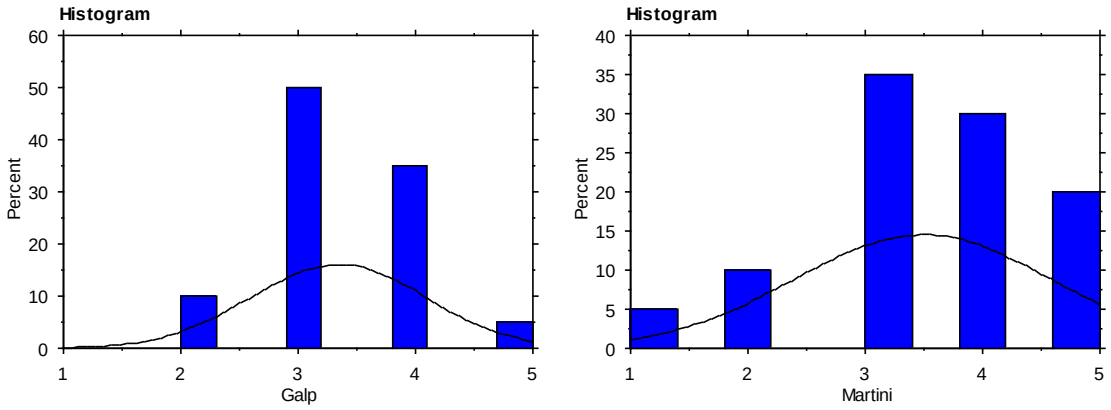

Figure C.6 Representation of the distribution of the scores given to the brands Galp and Martini.

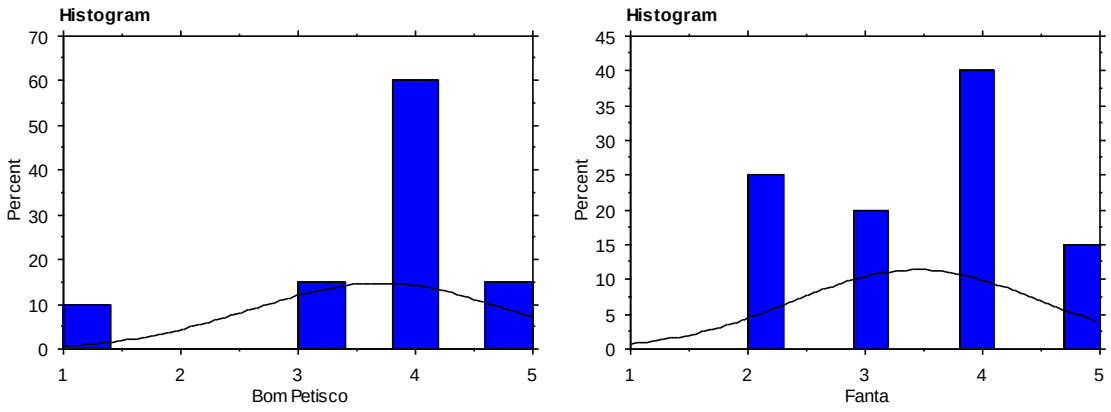

Figure C.7 Representation of the distribution of the scores given to the brands Bom Petisco and Fanta.

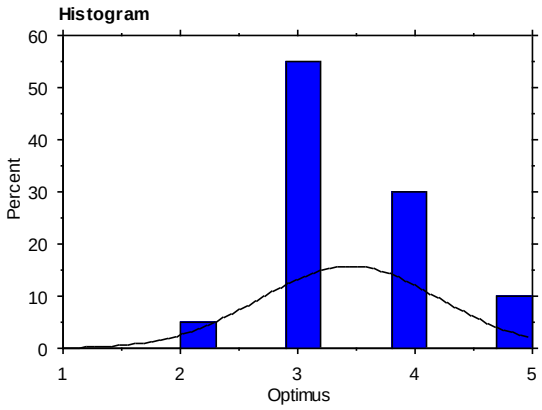

Figure C.8 Representation of the distribution of the scores given to the brand Optimus.

Appendix D

Table D.I Unpaired t-tests comparing for each ad the scores that the three groups (Dl, I and L) gave.

Ad	Groups	Mean Difference	DF	t-Value	P-Value
Bom Petisco 1	DL, I	-2.000	2	-2.828	0.1056
	DL, L	-1.250	12	-1.588	0.1383
	I, L	-0.750	12	-0.953	0.3596
Bom Petisco 2	DL, I	-2.000	2	-	>0.9999
	DL, L	-2.083	12	-2.860	0.0144
	I, L	-0.083	12	-0.114	0.9108
Optimus 1	DL, I	-1.556	8	-	-
	DL, L	-2.500	5	-	-
	I, L	-0.944	13	-2.325	0.0369
Vodafone 1	DL, I	-0.333	2	-	-
	DL, L	-0.750	11	-	-
	I, L	-0.417	13	-0.566	0.5811
Vodafone 2	DL, I	-1.333	2	-	-
	DL, L	-1.000	11	-	-
	I, L	-0.333	13	-0.570	0.5783
Martini 2	DL, I	-1.100	5	-1.231	0.2729
	DL, L	-1.500	9	-2.258	0.0504
	I, L	-0.400	12	-0.570	0.5783
Millennium BCP 1	DL, I	-0.643	9	-2.258	0.0504
	DL, L	-1.100	7	-2.925	0.0222
	I, L	-0.457	10	-1.721	0.1159
Millennium BCP 2	DL, I	-1.000	9	-1.382	0.2004
	DL, L	-1.200	7	-1.440	0.1930
	I, L	-0.200	10	-0.281	0.7846
Galp 1	DL, I	0.750	8	1.434	0.1894
	DL, L	0.000	6	0.000	-
	I, L	-0.750	12	-2.571	0.0245
Fanta 1	DL, I	-0.750	6	-0.933	0.3867
	DL, L	0.000	10	-1.432	0.1826
	I, L	-0.750	10	-0.394	0.7020
Fanta 2	DL, I	-1.000	6	-1.477	0.1901
	DL, L	-1.000	10	-1.613	0.1378
	I, L	0.000	10	0.000	-

Table D.I Unpaired t-tests comparing for each ad the scores that the three groups (Dl, I and L) gave. (Continued)

Ad	Groups	Mean Difference	DF	t-Value	P-Value
Sumol 2	DL, I	-0.500	2	-1.000	0.4226
	DL, L	-0.583	12	-0.736	0.4758
	I, L	-0.083	12	-0.103	0.9195
Delta Cafés 1	DL, I	-	-	-	-
	DL, L	-	-	-	-
	I, L	-0.875	14	-1.698	0.1117
Delta Cafés 2	DL, I	-	-	-	-
	DL, L	-	-	-	-
	I, L	-0.625	14	-1.330	0.2049
Nespresso 1	DL, I	0.333	5	-	-
	DL, L	-0.333	8	-	-
	I, L	-0.667	13	-1.493	0.1593
Nespresso 2	DL, I	-0.667	5	-	-
	DL, L	-1.444	8	-	-
	I, L	-0.778	13	-1.936	0.0750
CGD 1	DL, I	-0.667	8	-	-
	DL, L	-0.833	5	-	-
	I, L	-0.167	13	-0.384	0.7075
CGD 2	DL, I	-0.889	8	-	-
	DL, L	-0.833	5	-	-
	I, L	-0.056	13	0.137	0.8933
CTT 1	DL, I	-	-	-	-
	DL, L	-	-	-	-
	I, L	-0.633	14	-1.969	0.0691
CTT 2	DL, I	-	-	-	-
	DL, L	-	-	-	-
	I, L	-0.967	14	-2.412	0.0302