

# The Asymmetry of the Brain and the Choice of Purchase: An Application of Electroencephalography–EEG Evidence on Consumer Neuroscience Tests

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**Abstract:** The main objective of this pilot study was to try to prove by a test of consumer neuroscience, if the activity in the frontal cortex and its asymmetry, could predict the choice of purchasing a product or a service. An exploratory research was performed with 21 subjects, skilled (10 women and 11 men) were collected. Aged between 18 and 53 years, all were in good health at the time of enrollment and had normal psychiatric and neurological examination. The subjects should observe some stimuli of marketing (brands) and choose one to buy it without expressing it orally. The asymmetry of the brain, where the left hemisphere in the frontal region increased activity, affected the positive decision-making (choice of a brand for our study), vs lower activity in the frontal region of the right hemisphere. It could also pose a plausible hypothesis about the "power" brand in the decision-making choice and purchase. Because 95% of the subjects chose well-known brands and found that the trend of dominance of the left hemisphere over the right and the oral statements by the participants in the test. In addition, the Electroencephalogram (EEG) was a very useful tool to test consumer neuroscience.

**Keywords:** Consumer Neuroscience, Neuromarketing, Electroencephalography

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## 1. Introduction

Emotional processes evoked by the brain influence the consumer decision to purchase or not a particular product or service. These emotional processes are evoked by exposure to marketing stimuli auditory and / or visual, such as television advertisements, posters, radio ads, etc. Additionally, marketing stimuli generally have a brand that identifies the product or service statement. So that the product or service, identified by their brand, should evoke an emotional process, approach or withdrawal (frontal asymmetry hypothesis) in the brain of the potential consumer. The big question posed in this pilot study is, if whether throughout consumer research and supported by one of the tools of neuroscience, the electroencephalograph - EEG, can predict whether the emotional response captured by the EEG could be used as evidence the possible purchase or not the observed brand. Twenty-one healthy subjects, ten women and eleven men, watching a 17-inch screen at

intervals of five seconds by stimuli, well known branded versus products with "generic" brand meanwhile was recording the electrical activity in their brain.

## 2. Emotion and Purchase Decision

Emotions are very complex and rather difficult to detect causality the complexity of a wide range of different processes whose mutual relations it is not clear yet. There are hundreds of terms to refer to mental states and is commonly confused with feelings in this regard Damasio (1994) suggests that not all feelings are related to emotions and unlike some feelings can be based on some emotions such as joy, sadness, anger, fear and disgust, suggesting that stimuli generate somatic markers that guide human behavior into two pleasurable or aversive ways and somatic markers are generated in the prefrontal cortex, particularly the prefrontal cortex ventromedial region keeping memory of punishments and rewards.

Minsky (2010) raises a very interesting question in relation to emotions and feelings: Why are emotions and feelings so hard to describe? Because there are easier to recognize than to describe them. However, one could accept his explanation of the emotional process, as those bodily changes produced directly by the perception of the fact that excites us, and that the process feels these changes as that occur is: the emotion.

To understand the emotional processes, neurosciences play a very important role. The aim of the neurosciences to discover what happens inside the brain (Emotions, feelings, motivations, desires, etc.). This approach has been developed about a century ago, by the end of the twentieth century and how it relates to the main purpose of marketing. It is to understand the subjective world of the consumer as a point of convergence was found: Neurosciences + marketing = Neuromarketing. Therefore, marketing supported in the neurosciences want to manage brands (offering), with deep knowledge of consumer brain (Attention, emotion, intention, motivation, memory, decision) who is who buys.

In addition, to try to understand how marketing stimuli process purchasing decision, an interesting study was overtaken by Plassmann et al (2008), Perrachione and Perrachione (2008) approaching the neurosciences to marketers in order to interact developed better models for understanding the behavior of the consumer's brain and emotions. Gordon (2008) makes an interesting approach from a more philosophical perspective on emotions and reward processes as a contribution to consumer research by proposing a vision "neurophysiology". Shiv (2007) and in the same line of research Lerner, Han and Keltner (2007). in an article summarized, concrete and very entertaining, includes a temporal analysis of ATF model (Appraisal-Tendency Framework), in relation to the role of emotions in decision-making. And compared to the REA model (based Affect Evaluation and Regulation).

With the purpose of establishing the relationship between the choice of brand and the regions of brain activation with the subjective world inside of the consumer, we must distinguish systems or interconnections of the brain and which ones are responsible for processing these stimuli and generate or not an answer in response to that stimuli. Several authors who generally do not use neuroscience to try to divide or parcel out the human brain in specific areas, explain what zone "fire" emotions, motivations, desires, etc. On the other hand, there are also various authors who are opposed to be a "division" of the brain. Solms & Turnbull (2004) explain that can be used "theoretical models" such as the limbic system, to try to explain how emotional processes works. The term is often used as if referring to an anatomical structure, but is actually a theoretical concept about a group of structures in the concept of many neuroscientists, they are linked in a meaningful way from the functional point of view. Because it is a theoretical concept rather than something concrete, other neuroscientists include different structures within the term "limbic system". It is therefore a vaguely defined entity whose very usefulness is questioned by other neuroscientists. However, the "limbic system" includes the

following structures: thalamus, amygdala, hippocampus, fornix, mammillary body, basal forebrain nuclei, anterior cingulate turn.

More in detail, numerous studies have shown that the amygdala is a brain region that involves the regulation of negative emotions such as anger and anxiety and it is connected to a front region of the cerebral cortex, Davidson (1993), Cohena et al (2015). They have also discovered that individuals with problems in emotional regulation have a reduced orbitofrontal cortex. Petrovic et al (2015).

### 3. EEG and Hemispheric Asymmetry

The dimensions of emotion can be summarized in two: The first is the Arousal that translates into time when "Enable / Disable" emotion. The second dimension is the Valencia that is categorized into pleasant-positive or negative-unpleasant. For marketing, it could discover these dimensions of emotion, you can benefit from neuropsychology, an example is presented in Madan (2010), who studies how the brain is affected psychologically by marketing and advertising; proposing that the medial prefrontal cortex ( mPFC) is correlated directly with a preference and / or choice. In this regard and supported with neuroscience tools as EEG (electroencephalograph) which captures the electrical signals produced by the brain, with a ratio of milliseconds, at the time of neuronal synapses; they are amplified many times by this apparatus which allows to capture Mayor, Good & Ochoa (2013), Quesada et al (2007), Petrovic, et al (2015), Cohena et al (2015). Supporting the approach of discovering emotional processes Sanchez and Roman (2004) propose that the classic brain structures involved in emotion were the amygdala and hypothalamus, but recently have been discovered crucial structures involved in emotional processes, such as bark prefrontal, with a particular impact on the orbitofrontal and medial.

Application of neuroscience tools as the EGG for marketing studies is not innovative; you can find its applications from the early 70's. it Ohme, Reykowska, Wiener, and Choromanska, (2009), revealed in a study of two advertisements in television, consumers do not consciously noticed a subtitle change (on purpose) in one of the scenes of one of the commercial consciously but the brain registered and the behavior changed related to the scene transformed. Using the EEG shows that in general terms the left frontal area is involved in the experience of positive emotions such as joy, interest, happiness. The right frontal region involved in the experience of negative emotions such as fear, disgust and sadness. Following this line of brain asymmetry, these authors one year after the publication of his article, Ohme, Reykowska, Wiener, and Choromanska (2010), reinforce its approach, demonstrating that our "window to the conscience" "completely open to presented the 300ms after the stimulus.". This means that most of the events presented below this threshold, and are registered by our brain cannot be reported verbally. Concluding that there is sufficient evidence that some psychological processes, particularly those that occur

beyond our conscious perception can be better understood by analyzing the consumer brain with EEG and bodily responses. Carretié & Iglesias (1992) had already proposed that occurred before 300 ms, and clarify that such studies are based on analysis of evoked potentials P300, we should know very well the methodology of recording and the correct interpretation of the signals obtained in relation to evoked potentials there is no absolute truth of how to interpret correctly, these evoked potentials may contain one or more waves produced by a neural source. Thus the suggested approach is to measure the amplitude on the baseline. With the same purpose in a study in alcoholic patients Quesada et al (2007) of visual and auditory evoked potentials, focusing on P300. Explaining very well the Alpha, Beta, Delta and Theta waves.

Davidson (1998), Davidson (2004), Lee et. al (2012) argue that the prefrontal cortex along with other neural circuits, it is crucial to establish how the brain implements emotional and motivational processes. Also it supports the dorsolateral prefrontal cortex sector is mainly associated with cognitive control. Proposes a circuit composed of the prefrontal cortex, amygdala, hippocampus, insula, and anterior cingulate, which in their interaction play an important role in the features of emotion. Davidson (2004 b) investigates the influence of emotion in association with peripheral biological circuits and result in health or disease. Explains the "Affective Style" consisting of individual differences in the reaction and emotion regulation. Exposes the prefrontal cortex which is subdivided into Dorsolateral PFC, PFC and Orbitofrontal ventromedial PFC, and having functional differences in the brain's hemispheres, toward emotional processes. A visual stimulus (negative Video) produces right prefrontal and anterior temporal electrical activity. In contrast, the induced positive affect evokes an opposite pattern of asymmetric activation. The ventromedial prefrontal cortex has been implicated in the anticipation of future, positive and negative emotional consequences. And the relationship between the prefrontal cortex and amygdala

in the recognition of negative emotions. While the amygdala produces changes in behavior in response to stimuli, the prefrontal cortex inhibits these behaviors with guidance from the top down, Davidson (2012) demonstrates in his fMRI study presenting negative images produce activation of the amygdala and regulation of the prefrontal cortex.

## 4. Method

The method used in this pilot study was based on a modification itself of the methods used by Telpaz, Webb & Levy (2015) and Ohme et. al (2010). In order to observe the presence or absence of patterns in the activation of brain regions in the presence of stimuli (pictures) marketing, brain signals participants through an electroencephalograph brand NCC Nation were collected, with a montage 8 channels located in the frontal cortex (Fp1, Fp2, F3, F4, F7 and F8), the reference electrodes located in the mastoid and the general location 10-20. All subjects were informed before experimental procedures in accordance with the Declaration of Helsinki consent was obtained. The electroencephalograph is non-invasive procedure.

### 4.1. Participants

Data from 21 healthy subjects, skilled (10 women and 11 men) were collected. Aged between 18 and 53 years ( $m = 27$ ;  $SD = 9.9$ ). They were invited to participate in this pilot study previously reported, and paying them a value of \$ 20 for two hours for their time. All were in good health at the time of enrollment and had normal psychiatric and neurological examination. Exclusion criteria were any active or history of a major psychiatric disorder (manic depression, schizophrenia, Alzheimer's disease poorly controlled); any disease that may affect current or past brain function; drug or alcohol abuse; and any history of head trauma, brain surgery, skull defect, stroke or transient ischemic attack or stroke in previous MRIs.



Figure 1. Consolidated slides presented to participants.

#### 4.2. Procedures

Participants were located in an isolated room without noise and dim light that invited comfort and relaxation. Sitting in front of a 17 inch monitor, where they would see a series of images that were presented in two phases. In Phase 1, they were asked to remain with the eyes closed for two minutes and after this time, two additional minutes with eyes opened. In order to establish the baseline for capturing EEG signals. In Phase 2, participants needed to watch carefully a series of slides that were to appear on the monitor. Each slide contained two different products. The subjects should "mentally" (without verbalizing anything), choose one of the two products as if they were going to buy it. Each pair of products presented, had duration on the screen approximately of five seconds. In Figure 1 these products were presented to the six pairs of participants. In Phase 3 participants were asked what brand they had chosen of the products observed.

#### 4.3. Description of Stimuli

Six pairs of consumer health products were chosen. One of the products of each selected pair was a highly recognized brand and high positioned in the consumer's mind.-The other pair was an unknown or little brand recall. In addition, two of the pairs (Coke and Colgate) presented with a much lower price for the unknown brand, to try to establish whether the price could affect the purchasing choice of the participant.

#### 4.4. EEG Recording

Low frequency filters under one (1) Hz and high frequency lower than 70Hz, with a sensitivity of 7 Mv / mm, a speed of 30 mm / second were used. Calibrations horizontal and vertical a second 100 Mv.

When the subject was asked dealt with and discriminate stimuli (products), that differ from each other by their brand, discrimination occurred in certain cortical areas with a wave of positive polarity to a large extent (10 to 20 microvolts), and a latency around 250 to 600 milliseconds, these parameters are influenced by age, registration area and the road is stimulated in turn are important when evaluating the results of the study, because in essence reflect the speed with which certain information is processed by the brain (latency) and the ability to distribute and focus attention on certain characteristics of the stimuli used in the test (amplitude).

### 5. Results

EEG data were exported directly from NCC Nation. Edf a file extension and this in turn became a .txt file extension, and finally exported to SPSS (17) software. In order to resolve the central question of this pilot study: Can the brain asymmetry check when choosing a brand? In addition, the sub-questions: Are the most recognized brands that prevailed over the less recognized ones. Is EEG a reliable tool to predict consumer-buying behavior?

The distribution of 21 healthy, right-handed (10 women, 47%

and 11 Men, 53%) subjects. Aged between 18 and 53 years ( $m = 27$ ;  $SD = 9.9$ ). First, it is important to note that 20 of 21 (95%) participants reported having tests chosen the most recognized brands against the less known brands. Given the sample size of 21 subjects, test for related samples they were applied, in order to answer the questions within the larger overall objective of this pilot study. Tests are desirable since it is intended to check for statistically significant differences in brain activation mV measurement between pairs of electrodes. Given that those electrodes odd nomenclature (Fp1, F3, F7), capture signals of interest of left hemisphere and nomenclature electrode pair (Fp2, F4, F8), the right hemisphere capture signals of interest. And wishing each test the hypothesis of brain asymmetry, if there is greater electrical presence in the left hemisphere (approach) or in the right hemisphere (Withdrawn). In order to establish the statistical differences between pairs of electrodes, a value was established.  $\alpha = 0.05$ , therefore the  $p \leq \alpha$  values used to determine the significance of the test.

Initially will be presented in figures 2 and 3 the maps of brain activation taken directly from the EEG-NCC Nation. However, it is relevant to highlight that this analysis is suggested guidance descriptive, given that these maps are generally not very accurate, because they attempt to summarize and average all brain activity in relation to the fitting of the previously selected electrodes. Therefore, later presents the summary table of the t tests applied to each of the six pairs of brands evaluated.

In Figure 2 shows, the distribution almost symmetrical brain activity, averaged for all the stimuli presented to the participants of the pilot study, for electrodes FP1 and FP2, reflecting with clarity the indication of non-dominance of a hemisphere in front of the other. In contrast with the figure 3, that if there is a clear dominance averaged of electrodes F3 and F7, in relation to the stimuli observed by the evaluated subjects.

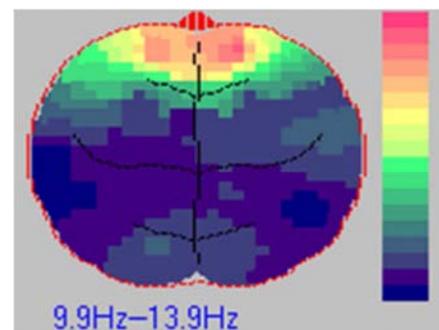


Figure 2. Map of the alpha rhythms for electrodes FP1 and FP2.

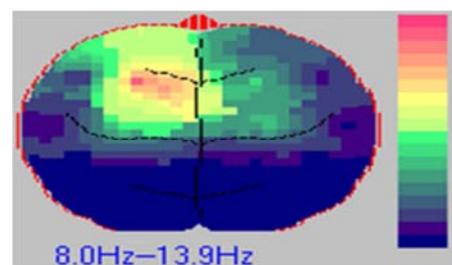


Figure 3. Map of the rhythms alpha for electrodes F3 y F7.

Complementing the previous descriptive analysis, the following is a summary of the results of the t tests, for each one of the pairs of brands evaluated, with the aim of

establishing whether there is dominance of a hemisphere in front of the other, in Table No.1:

*Table 1. Values of test, with  $\alpha = 0.05$  and  $p \leq \alpha$ .*

PAIR	ELECTRODES	MEDIA	SD	FD	T	SIG
BANCOLOMBIA VS AGRARIO	Fp1 – Fp2	-1.15	6.309	20	-659	.522
	F3 – F4	11.000	3.512	20	11.293	.000
	F7 – F8	8.846	2.512	20	12.700	.000
NESCAFÉ VS ÉXITO	Fp1 –Fp2	-.077	7.053	20	-.039	.969
	F3 – F4	8.077	4.030	20	7.226	.000
	F7 – F8	9.923	3.546	20	10.089	.000
AGUILA VS HEINEKEN	Fp1 – Fp2	.154	5.161	20	.107	.916
	F3 – F4	10.154	3.555	20	10.297	.000
	F7 – F8	9.231	3.193	20	10.425	.000
COCA COLA VS AFRI	Fp1 – Fp2	.615	7.805	20	.284	.781
	F3 – F4	11.154	3.848	20	10.451	.000
	F7 – F8	9.692	4.270	20	8.185	.000
FORTIDENT VS COLGATE	Fp1 – Fp2	.231	6.930	20	.120	.906
	F3 – F4	10.308	5.298	20	7.015	.000
	F7 – F8	7.846	4.318	20	6.552	.000
McDonald’s VS EL CORRAL	Fp1 – Fp2	1.462	4.371	20	1.206	.251
	F3 – F4	10.308	2.898	20	12.825	.000
	F7 – F8	10.625	3.367	20	12034	.000

Seen in the table 1, there is a tendency to dominance of the left hemisphere over the right hemisphere in the electrodes studied, which were located only in the frontal region of the subjects. It cannot ensure a "total" dominance of the left hemisphere because for all six pairs of products tested, Fp1 vs Fp2 electrodes do not present, statistically significant differences in frequencies, all with  $p > \alpha$  value.

In the remaining electrodes F3 and F4 vs F7, F8, there are statistically significant differences with p values  $\leq \alpha$ . If you look closely at the values t of these comparisons, we see greater activation for the McDonalds brand, followed by Bancolumbia brand and third would be the brands Coca Cola and Heineken is presented. At this point it could be plausible confirmed the hypothesis of Davidson (2004) and Damasio (1994), about the role of the ventromedial prefrontal cortex in emotion regulation and decision-making.

## 6. Conclusions and Future Directions

Heading to answer the main question of this pilot study and two sub-questions, it could answer the main question with the data obtained if a trend is seen with increased frequency of alpha rhythms in the left hemisphere than in the right hemisphere, when deciding a purchase of a particular product. Resulting clear evidence of the proposal of Davidson (2004), about the asymmetry of the brain, where increased activity of the left hemisphere in the frontal region, affect the positive decision-making (choice of a mark for our study), vs lower activity in the frontal region of the hemisphere right. Referring to the first sub-question, it could also pose a plausible hypothesis about the "power" brand in the decision-making choice and purchase. Because 95% of the subjects chose well-known brands and found that the trend of dominance of the left hemisphere over the right and the oral statement by the participants in the test. In addition,

in response to the sub-question three, the EEG it is a very useful tool for testing of consumer neuroscience, with their respective advantages and disadvantages. As it is the cost advantages compared to fMRI and temporal resolution. The disadvantages have the support of qualified personnel for operation and interpretation and tension and annoyance as attaching electrodes to the participants.

However, you should take special care in the restrictions that present the tests EEG, because the sample sizes will surely be small, for the deployment costs, reflecting on the generalization of the results. However, you can balance this weakness, with a rigorous design of the model and method to continue. In this regard, the EEG tests take an incalculable value, by its non-invasive nature and because it meets the great purpose of consumer neuroscience go beyond verbal responses and "filtered" by the conscious mind.

## Research Implications/Limitations

You should comprehend the restrictions that presented the EEG tests because of the small sample sizes. This restriction was due by increased costs reflecting on the generalization of the results. However, you can balance this limitation by the use of a rigorous design of the model and method. In this regard, the EEG tests have an great value by its non-invasive nature and because it meets the great purpose of consumer neuroscience that go beyond verbal responses and "filtered" by the conscious mind. The EEG tests were restricted due to the small sample size because there were money restrictions to obtain larger samples.

## Practical Implications

The EEG is a very useful tool for testing consumer neuroscience, with advantages and disadvantages. Some of

the advantages compared to Magnetic resonance imaging (MRI) and temporal resolution is adequate cost. The disadvantages are to have the support of qualified personnel to perform and interpret the tests.

## Originality

This article provides great originality value because of its limited publications in high-impact journals across countries such as Colombia, especially where tests were performed about neuroscience of the consumer and particularly using EEG tests. It adds indistinctively value given that the study verifies the prediction factor of consumer purchasing beyond the traditional techniques applied in the market research.

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