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Right evaluation of marketing stimuli with neuroscience. An electroencephalography experiment

Antonio González-Morales [1]

University of Seville, C/ San Fernando s/n, CP: 41004, Avenida de Andalucia 2, 1°A, CP: 41005, Sevilla, Spain

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A B S T R A C T

Emotional valence is very important in order to create the imprint of the memory of brands and companies in the minds of consumers and to create an adequate perception of companies and influence their purchasing decisions. Therefore, it is a main objective of neuromarketing and neuromanagement. A very suitable method in neuromarketing and neuromanagement studies is the ecological electroencephalography paradigm (in time domain). Confirming that ecological electroencephalography is useful to appreciate the valence generated with visual stimuli in marketing actions is the problem of this experiment. Therefore, the objective of this work is to confirm or refute the hypotheses that have been raised in this regard. Since the theoretical corpus included in this work has been obtained mainly by functional magnetic resonance imaging and other electroencephalography techniques in addition to ecological electroencephalography, this knowledge is sometimes directly assumed for EEG in general and is sometimes not very precise. It has been found that stimuli with positive valence generate more brain activity in the left hemisphere than in the right, as proposed by the first hypothesis. However, negative valence stimuli do not generate greater brain activity in the right hemisphere than in the left, as proposed by the second hypothesis.

1. Introduction

Traditionally, decision making in shopping has been studied with questionnaire, interviews and other market research theccniues. However, the researchers McDonald (2003) and Franzen and Bouwman (2001), have said that the professionals who performs the typical opinion studies and market research, have a great influence on the subjectivity of the results. Respondents may lie, as Huelva and y Chaves (2002) show or do not know what they want according to Hernández Ballesteros (2014). Neuroimaging data would give a more precise indication of consumer preferences, than traditional market research studies and it is free of subjectivity (Ariely & Berns, 2010).

The executive functions such as logical reasoning or the decision making process in shopping had been believed to be perfectly rational, contrary to what really happens, since human behaviour is not perfectly rational. It has been defined by two types of executive functions: “Metacognitive and emotional, depending on the different brain systems that act. The metacognitive functions seem to be useful in the solution of external and emotionally neutral problems, but in social situations and biological impulses, the rational capacity decreases significantly, etc. The current evidence of executive functions that were considered metacognitive mostly requires the emotional” (Ardila, 2008).

1.1. Emotions in marketing

Ardila (2008) has proposed that emotion has great importance in the brain activity of executive function. Confirming this hypothesis, researchers Lee et al. (2007) and Álvarez (2007), have confirmed the importance of emotion in neuromarketing.

Antonio González-Morales the president of the Spanish Association of Neuromarketing and Neurocommunication AENENE defines Neuromarketing as “the application of neurosciences in order to facilitate and improve the creation, communication and exchange of actions, services and products of value among groups and individuals who need and want to satisfy their needs through these exchanges” (González-Morales et al., 2020).

People shop depending on the emotions generated by the products, brands, etc., and these emotions have a strong on how people decide purchases. The emotions generated strongly influence how people buy, how traces of memory are created, how they perceive a brand or company, etc. (Morin, 2011). A large number of subconscious elements,

E-mail address: agmorales@us.es.

[1] Avenida de Andalucia 2, 1°A, CP: 41005, Sevilla, España

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which cannot be studied through traditional market research methodologies, influence this cognitive process of shopping. "The application of neuroscientific methods to analyse and understand human behaviour related to markets and marketing" (Lee et al., 2007, p.200) (Lee et al., 2007). Automatic and rapid cognitive processes, without direct volitional control make most of the economic decisions (Bargh & Chartrand, 1999).

Moltó et al. (1999 (Moltó et al., 1999); 2000 (Moltó, 2000); 2013 (Moltó et al., 2013)) define the emotion in a bi-dimensional model "one is the Valencia that goes from pleasant (approach) to unpleasant (avoidance) and the other is the Arousal or Activation that goes from excited even calm".

"Emotion consists in a change in the states of the body and brain in response to a concrete fact". The body changes depend on external stimuli and influence the attention, memory, etc., which are essential for making rational decisions. The emotion are the changes in the states of the body and brain originating from external stimuli that influence cognitive processing (Damasio, 1994; Damasio, 2005).

Appetitive stimuli of positive valence generate approach reactions and vice versa (Sabatinelli et al., 2005).

Bradley & Lang's theory of emotion proposes two motivational systems, one for appetitive actions and the other for defence actions, and they organize emotions. Motivation theory proposes two emotional dimensions, hedonic valence (pleasant or unpleasant, that is, appetite motivation or defence motivation) and excitation (the degree of motivation activation) (Vos et al., 2012).

With the help of functional magnetic resonance imaging, it is known that there are areas of the left dorsolateral prefrontal cortex (PFC) that are activated more, with positive rather than negative images. There are areas of the right ventrolateral PFC that are activated more with negative images than with positive ones. The PFC is fundamental in the emotional evaluation and in the memory footprint. Emotion and emotional valence are very important, which through the PFC influence cognitive functions (Dolcos et al., 2004).

The activity of the brain in the PFC is asymmetric, and propose the valence hypothesis (Dolcos et al., 2004). Which mean that the left PFC domain in the brain processes positive emotions, and the right PFC domain in the brain negative emotions (Davidson & Irwin, 1999).

That emotions influence our behaviour via emotional action tendencies is the core of many emotions theories. There is a greater activation of the left-brain hemisphere before approach provision, and a greater activation of the right side with the disposition towards avoidance (Sutton & Davidson, 1997).

1.2. Generation of electrogenesis by the emotions

The human brain produce brain activity creating very small currents that circulate by the brain giving rise to the electrical potentials. These electrical potentials can be measured with the electroencephalograph when they synchronize in a high number to create a measurable bioelectric signal, the electrogenic capacity (Nunez & Srinivasan, 2006).

Position of electrodes by EEG is standardized in "Positions of the International System 10:20" Barea (2010) (Barea, 2010) (Fig. 1).

There is a greater activation of the left hemisphere with the approach disposition (positive valence) and of the right hemisphere with the avoidance disposition (negative valence) measured with electroencephalography Sutton and Davidson (1997). The left prefrontal cortex is important in the approach and the right prefrontal cortex is important in the avoidance (Balconi et al., 2009). There exists a greater activity in the left frontal brain region with positive emotional experiences or with the motivation to approach an object (Harmon-Jones, 2003; Vecchiato et al., 2014; González Morales, 2018; Cherubino et al., 2015).

Event-related potential (ERP) is normally used to study the brain reaction to stimuli with electroencephalograph, but ERP is not adequate for evaluating dynamic stimuli. With an ecological paradigm this problem can be solved.

To know, if these statements are corrects for the experiments with an electroencephalography ecological paradigm (in the time domain), the author of this research has been looking for experiments that study the brain activity by an ecological electroencephalography paradigm, in which the statistical relationship between these brain activity patterns and the emotional valences of the images obtained in a scientific way is subsequently studied.

The ecological paradigm of the EEG technique is capable of measuring fluctuations in voltage or electrical potential on the scalp caused by the concomitant electrical activity of a population of neurons. These voltage fluctuations can be characterized in terms of spectral content (EEG bands or rhythms) "the one used in the experiment and that some researchers call the ecological paradigm (Astolfi et al., 2011; Vecchiato et al., 2014).

This paper has been structured as follows: First, it can be seen that there is an abstract in which the main conclusions of the work are summarized. Subsequently, an introduction is presented, in which the problem to be solved is exposed, describing the importance of emotions in marketing, as well as the relationship between perceived emotion and brain activity generated by human beings. The starting hypotheses have been proposed and subsequently the materials and methods used in the experiment. The results are obtained from the study of the relationships

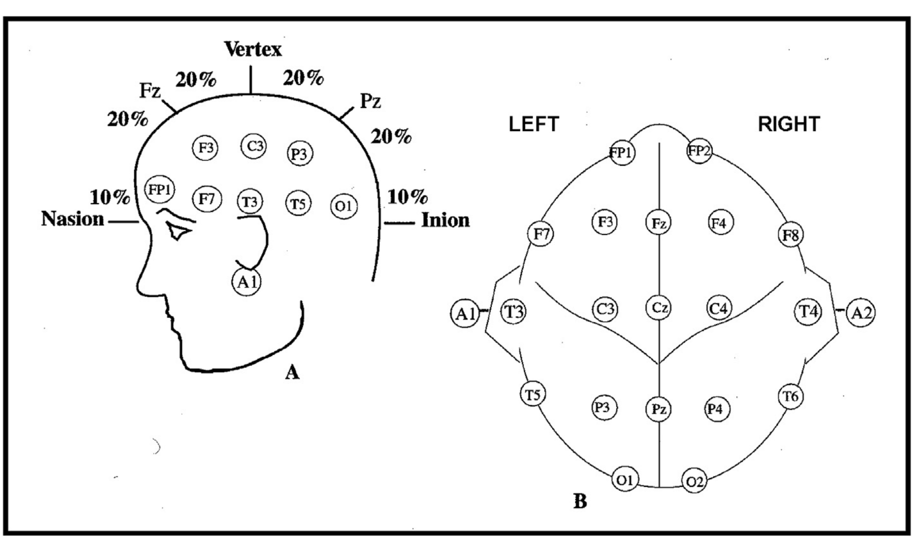

Fig. 1. Positions of the International System 10:20, obtained from Barea (2010).

between brain activity and the valences of the images, independently, for images of positive valence on the one hand and for images of negative valence for another, and from their statistical studies. The discussion has been conducted and the conclusions and limitations and future research have been described.

Hypothesis 1. In the ecological paradigm of electroencephalography, with positive stimuli (approach), the brain activity generated in the left hemisphere is greater than the brain activity generated in the right hemisphere.

Hypothesis 2. In the ecological paradigm of electroencephalography, with negative stimuli (avoidance), the brain activity generated in the right hemisphere is greater than the brain activity generated in the left hemisphere.

2. Materials and methods

2.1. Materials

An electroencephalograph NCC Medical CO., Mark LTD, model NATION 7128C has been used to record brain activity.

Normally, it is possible to use different types of images for advertising and marketing actions. To facilitate this experiment in a scientific way the author has decided to use images with the valence previously evaluated in Spain, because this experiment has been carried out in Spain. The images used were selected from Castellar et al. (2001), which are included in the "International Affective Imaging System" (IAPS) of Lang et al. (2008), which are the same images of the "International Affective Imaging System" (IAPS) by Lang et al. (1999).

Castellar et al. (2001) conducted an experiment in Spain to evaluate the emotional valence (positive-induce to approach and negative-induce to avoidance) of the images that are part of the "International System of Affective Images" (IAPS).

The images have been selected by the valence score in two categories: high valence and low valence, so two types of groups have been made in relation to valence: High valence (pleasant, the closest values to nine) and low valence (unpleasant, the closest values to one). As we wished to study the different brain reactions to images of the extreme values, no images of average values have been taken.

The format for enumerating the images is the following: "image number in the IAPS (valence value) name used in the experiment". The images selected as low valence images (<5), their values and the name used in the experiment are 3068 (1.44) Image33, 3069 (1.46) Image34, 3261 (1.53) Image35, 2688 (1.67) Image31, 3004.1 (1.46) Image32, 9360 (3.71) Image45, 9331 (3.07) Image44, 2753 (3.10) Image42, 5120 (4.28) Image43, 2722 (2.88) Image41. The images selected as high valence images (>5), their values and the name used in the experiment are 4670 (7.45) Image23, 4658 (7.11) Image21, 8185 (7.40) Image25, 4672 (7.31) Image24, 4669 (7.31) Image22, 2222 (7.69) Image13, 5811 (7.44) Image15, 1604 (7.21) Image12, 1603 (7.34) Image11, 2304 (7.09) Image14.

A laptop Medion CORE i7 laptop, 16 Gigabyte of Ram with Nvidia GeForce graphics card and a screen for the presentation of the images has been (an HP screen of 17''), have been used in the experiment.

The experiment was recorded in the Seville University.

2.2. Methods

A pilot study was conducted before starting the experiment. This pilot study was carried out with seven volunteers, mostly students from the faculty of psychology at the University of Seville. With this pilot study, it was possible to correct some small operational problems, providing a learning period in conducting this specific study. In particular, it was possible to think about the exposure times, the temperature in the room and the noises, and some other questions that could be corrected for the experiment.

An investigation was carried out following a modification of a cross-sectional quasi-experiment on a group of volunteers that made up the selected sample. The volunteers were selected using the non-probabilistic "snowball" technique. The experiment consisted of the presentation of visual stimuli previously evaluated in emotional valence by Castellar et al. (2001) for each of the selected images (independent scalar variable) while the empirical data of the brain activity of the hemispheres (dependent scalar variable) have been recorded. In addition, later we studied whether there was a relationship between the values of the emotional valences of the stimulus images (independent variable) with the brain activities measured (independent variable), according to the theory of the article and according to the normal distribution of each of the data used.

The experimental task consisted of observing twenty images unknown to the participants. It started with 21 s of gray screen. Subsequently, each image was displayed for 7 s and each stimulus image was alternated with a neutral gray image for 7 s each, in order to neutralize and stabilize the psychophysiological variables that had been recorded at the same time, according to Chang's studies., Chang et al., 2013.

The experiment was conducted between February and April 2016 with the specified equipment, following the manufacturer's instructions for use and the data recording was performed using the software provided by the manufacturer of the recording equipment. It was carried out on a non-probabilistic sample of volunteer university students with the statistical characteristics of N = 23, age M = 23 years, age DT = 7297 (age range 19–49 years). The experiment has been carried out individually for each component of the sample.

Prior to taking records, participants were contacted and informed of the experiment through the "Information Sheet to Participating Subjects", who have read and signed an "Informed Consent Form". The participants have been invited to sit in an armchair, the electrodes have been placed according to the manufacturer's instructions and with the 10:20 international system and the images have been presented on the screen. The images used in the experiment were unknown to the subjects and have been shown only once during it. Participants were told to pay attention to what they were going to see, staying still as much as possible and blinking as little as possible. They were also told that if they felt any discomfort they would indicate it immediately.

During the visualization of the images, the values of the brain activity were recorded. The data have been recorded at a recording rate of 128 Hz (the device records in microvolts). During the recording, the 50Hz frequency filter has been activated to avoid the interference of the electricity from the laboratory's electrical network and the impedances have been kept below the appropriate limit for the registration by means of the impedance control of the equipment.

The measured values of brain activity, after having carried out the appropriate treatment and the necessary calculations, have been related to the valence previously calculated by Castellar et al. (2001), for each of the selected images. The signals registered during the presentation of the images have been treated using the software EEGlab of Matlab, SPSS y Excel in order to study the appropriate relations.

The recording of brain activity has been carried out on the scalp with surface contact electrodes of chlorinated silver with a pad that is moistened with conductive saline. The electrodes were placed. The placement of the electrodes[2] has been according to International System 10:20 at points FP1, F7 and F3 for the left hemisphere and at points FP2, F8 and F4 for the right hemisphere, as shown in the screen-printing (Fig. 2).

The impedances were verified and the data was recorded according to the instructions in the equipment manual and taking into account the advice and instructions of the Spanish Association of Clinical Neurophysiology of Bauzano-Poley, E. (2010). Once the recordings were made

[2] The registration was carried out with the 19 channels of which the EEG consists, with the purpose of carrying out further studies.

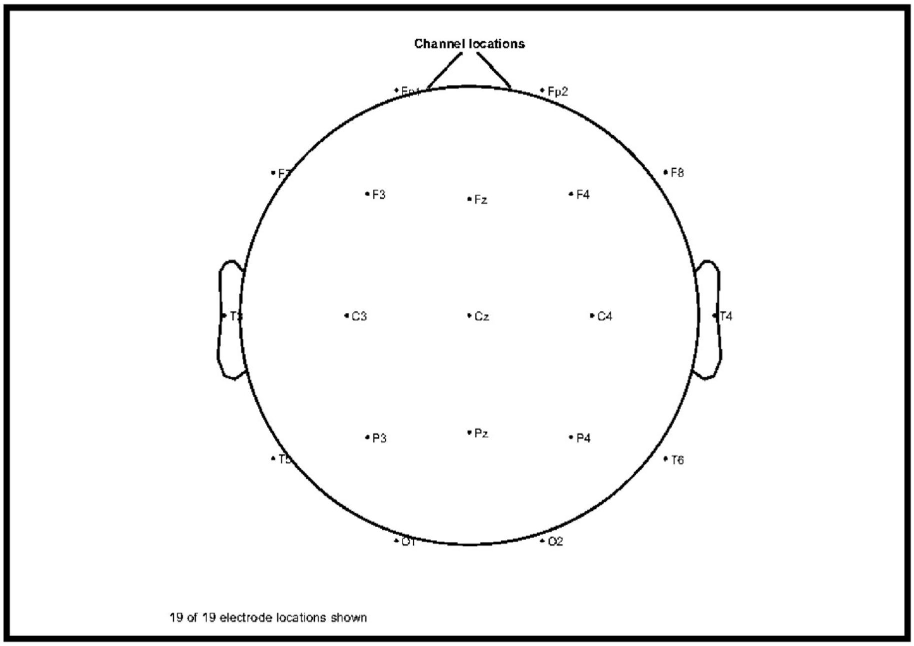

Fig. 2. Positions of the electrodes used in the experiment. Own image obtained from EEGlab. The 19 electrodes were organized according to the International System 10–20.

and prior to the statistical analysis, the verification was made that the data obtained did not contain errors or excessive artefacts.

The files were saved in.NED format and subsequently transformed to.EDF in order to be treated with EEGlab and to carry out the signal pre-processing. The signal has been processed by filtering high pass at 2 Hz and low pass at 30 Hz, which allowed eliminating the high frequencies characteristic of muscle artefacts. The remaining eye and muscle artefacts have been removed by Independent component analysis "ICA". This technique allows representing the information of the EEG in a space of statistically independent components and allows eliminating those components that correspond to artefacts. Subsequently, the EEG signal was reconstructed once the artefact components were eliminated. The triggers have been added, the data has been referenced to the average of all electrodes, so the average reference has been used. Finally the times corresponding to the presentation of each of the stimuli have been extracted. The study was carried out in the classical range of the alpha frequency, from 8 to 13 Hz.

The power of the brain activity for each image has been calculated by squaring the values of the electric voltage wave (μV) avoiding the subtraction of the negative values and thus obtaining the power in μV^2. The power in the alpha band (8–13 Hz) has been used, for which the EEG has been previously filtered between 8 and 13 Hz, so it only contained information related to the alpha band. This has been done for each of the electrodes used. Subsequently, the average of all the power data recorded during the entire stimulation period was calculated with each of the images, for each of these electrodes. This average value is the one that has been taken as the power of the brain activity for each of the images. It is very important to note that as Sutton and Davidson (1997) have indicated, low power values in the alpha band imply a high state of brain activity, while high power values in the alpha band imply a state of low cortical processing.

3. Results

The study of the relationship between the brain activity and the valence of the images has been carried out by comparing the brain activity of the prefrontal cortex area between the left and right hemisphere, as noted by the authors Davidson et al. (1990), Harmon-Jones (2003) and Dolcos et al. (2004). The study was carried out in the alpha band (8–13Hz), band proposed by the authors Sutton and Davidson (1997), for which, the EEG signal was digitally filtered in this frequency band by means of the EEGLAB software.

After the treatment of the signals of the tension obtained by electroencephalography (μV), the values have been squared, so the unit of data in terms of power is in microvolts squared (μV2) and they have been added independently the brain activities of:

- Left hemisphere (FP1, F3 and F7) for positive images (AC Hem Left_Positive).
- Left hemisphere (FP1, F3 and F7) for negative images (AC Hem Left_Negative).
- Right hemisphere (FP2, F4 and F8) for positive images (AC Hem Right_Positive).
- Right hemisphere (FP2, F4 and F8) for negative images (AC Hem Right_Negative).

The power values are (Table 1):

Next, we are going to develop the study of the relationships between brain activity and the valence of the images, independently, for images with positive valence on the one hand and for images with negative valence on the other.

3.1. Descriptive analyses and normality tests

Firstly, a study was done of Descriptive statistics of brain activity in power term in μV^2 (Table 2).

Prior to the analysis of significance, a normality test was carried out for samples below 50 individuals using the Shapiro-Wilks test, in order to determine the type of statistic appropriate for said analysis. With it, it has been verified if the degree of significance of the different variables is greater than 0.05, which would indicate that the variables would be distributed according to a normal variable. It was possible to verify that the variables do not follow a normal distribution, since according to the data obtained from the Shapiro-Wilk test shown in Table 3, a significance of 0.000 is obtained for all variables, less than 0.05, so variable values do not follow normal distributions.

The histogram, the Normal Expected/Observed Value graphic, and the box diagram of the brain activities in μV^2 of each hemisphere have

Table 1
Values of brain activity of each experimental subject registered in each hemisphere during the visualization of positive and negative images in μV^2.

Participant number	AC Hem Left_Positive	AC Hem Right_Positive	AC Hem Left_Negative	AC Hem Right_Negative
1	.96	1.31	1.07	1.67
2	1.54	1.69	1.54	1.73
3	1.18	2.73	1.21	3.17
4	2.43	1.11	2.80	1.13
5	3.78	6.02	1.56	3.01
6	1.15	1.96	1.16	2.02
7	5.12	2.70	4.66	2.20
8	1.70	1.89	1.74	2.03
9	1.54	2.65	1.24	1.95
10	.86	1.03	1.07	1.14
11	1.02	2.58	.99	2.35
12	.54	.85	.62	1.05
13	.90	1.03	.89	1.12
14	.66	1.12	.61	1.09
15	1.96	4.10	1.62	3.44
16	.83	.80	.87	.79
17	3.90	3.91	5.08	5.26
18	1.51	2.56	2.04	3.17
19	3.30	3.18	3.64	3.36
20	15.45	16.59	17.98	18.13
21	3.60	3.36	3.72	3.15
22	14.47	19.77	14.68	19.67
23	.92	.59	.98	.59
Average	3.01	3.63	3.12	3.62

Table 2
Descriptive statistics analysis of brain activity in power term in μV^2 of each hemisphere stimulation with images of positive and negative valence.

	N	Mínimum	Máximum	Medium	Typical deviation
AC Hem Left_Positive	23	.54	15.45	3.0139	3.97075
AC Hem Right_Positive	23	.59	19.77	3.6317	4.79461
AC Hem Left_Negative	23	.61	17.98	3.1204	4.38376
AC Hem Right_Negative	23	.59	19.67	3.6183	4.95253

Table 3
Values of the tests of normality of the potency of the cerebral activities of each hemisphere with images of positive and negative valence.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Estadístic	gl	Sig.	Estadístic	gl	Sig.
AC Hem Left_Positive	.281	23	.000	.586	23	.000
AC Hem Right_Positive	.331	23	.000	.571	23	.000
AC Hem Left_Negative	.293	23	.000	.563	23	.000
AC Hem Right_Negative	.384	23	.000	.529	23	.000

[a] Lilliefors significance correction.

been carried out before the positive and negative valencia stimuli. (Figs. 3–11).

3.2. Study of the statistical relationship

The study of the relationships between brain activity (CA) and valence has been carried out separately, according to the latter being positive or negative, and consisted of performing two Wilcoxon signed-rank test, one for positive images and, another for the negatives.

This statistic was used because the values of the variables were not distributed as normal distributions. It is used to check if two related measurements of a continuous variable without normal distribution have significant differences between them accepting the alternative

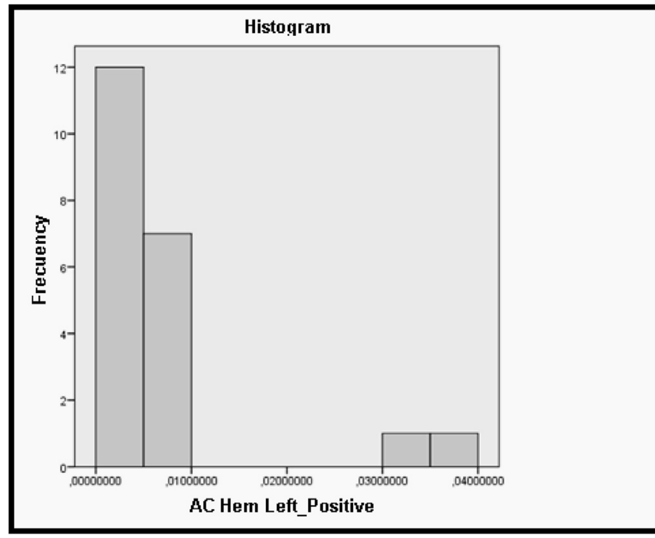

Fig. 3. Histogram of the cerebral activity of the left hemisphere with the positive images (μV^2).

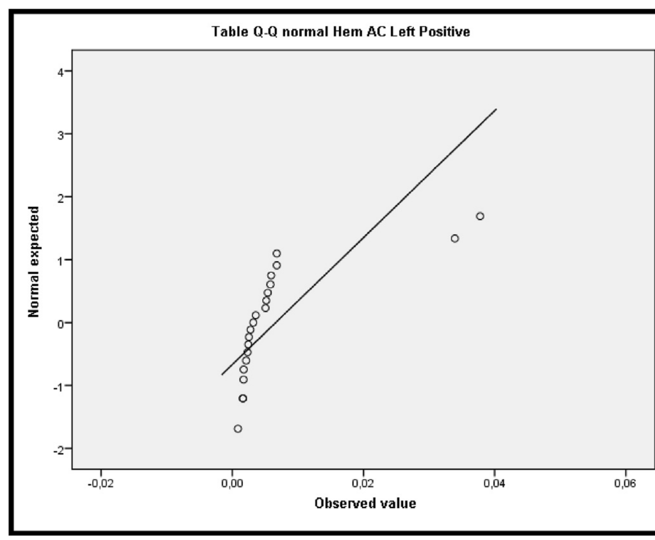

Fig. 4. Normal Expected Graph/Observed Value of the brain activity of the left hemisphere before positive Images (μV^2).

hypothesis (H1), or, if the differences between the statistical medians of the measurements do not have significant differences between them and are due to chance, the null hypothesis (Ho) is verified. It is desirable to know to know if the averages of the brain activity in each hemisphere vary significantly with positive images, as well as with negative images. The test was carried out using the SPSS software providing the results shown in Table 4.

The Wilcoxon test for positive images can be verified for positive images, $N = 23$ resulted in $Z = -2.312$, $p < .021$ (Table 4), the level of significance being less than 0.05. It can be said that the difference is statistically significant so the median of brain activity in the alpha band of the right hemisphere is significantly higher than that of the left hemisphere compared to positive images. Which means that the right hemisphere has more power in the alpha band, therefore it is less active than the left.

The Wilcoxon test for negative images can be verified for negative images, $N = 23$, a $Z = -2.038$, $p < .042$ (Table 4), the level of significance being less than 0.05. It can be said that the difference is statistically significant. The median of the brain activity in terms of power of the right

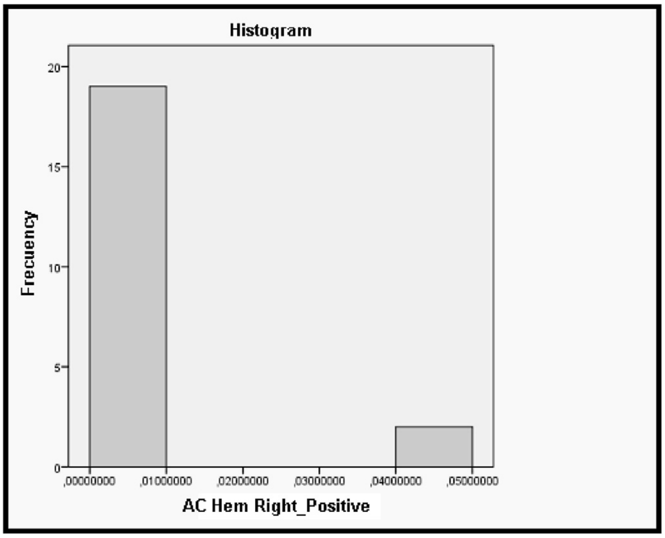

Fig. 5. Histogram of brain activity of the right hemisphere before positive images (μV^2).

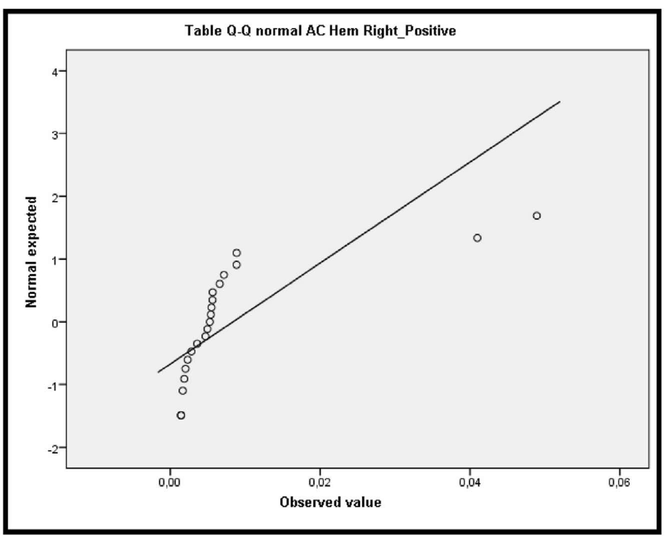

Fig. 6. Graphic of Normal expected/Observed value of the right hemisphere brain activity before positive images (μV^2).

hemisphere is significantly higher than that of the left hemisphere in the alpha band with negative stimuli (avoidance). Which means that the right hemisphere has more power in the alpha band, therefore it is less active than the left.

4. Discussion

The study of significance of the relationship between brain activity and positive and negative images separately, has been carried out by means of two Wilcoxon signed-rank test.

4.1. Positive images

The median of brain activity in the alpha band of the right hemisphere is significantly higher than that of the left hemisphere compared to positive images. Which means that the right hemisphere has more power in the alpha band, therefore it is less active than the left.

The first hypothesis "In the ecological paradigm of electroencephalography, with positive stimuli (approach), the brain activity generated

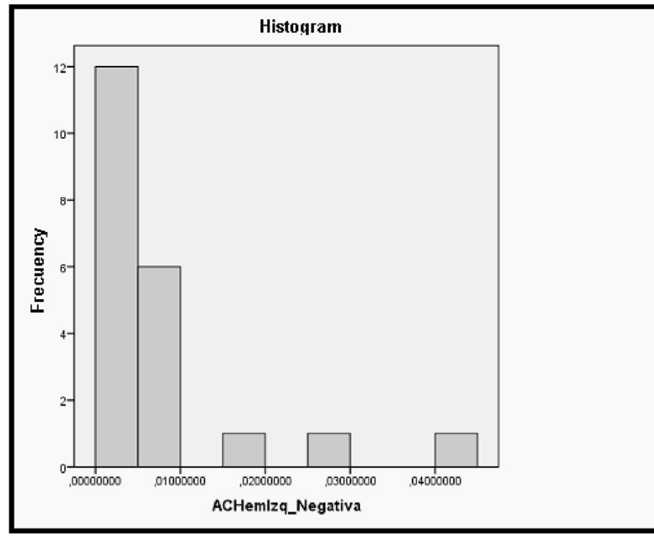

Fig. 7. Histogram of brain activity of the left hemisphere before negative images (μV^2).

in the left hemisphere is greater than the brain activity generated in the right hemisphere" has been confirmed.

The positive images have resulted in what was expected according to the majority of the authors consulted who support the valence hypothesis, having found higher levels of activity in the left hemisphere than in the right in front with positive emotional stimuli (Davidson & Henriques, 2000; Waldstei, Kop, Schmidt, Haufler, Krantz, & Fox, 2000; Shestyuk et al., 2019; Ciorciari et al., 2019)).

There are authors who support the valence hypothesis, but there are others who have found opposite results, such as the cases of Schellberg et al. (1993), Cole and Ray (1985) and Tucker and Dawson (1984), who They are in line with other results that found a specific frontal prevalence in response to emotional stimuli. (Cited in Harmon-Jones et al., 2003).

The differences found by these latter authors, as well as the results of the experiment for negative images, could be due to different types of stimuli, different subjects, different interpretations of alpha (activation or inhibition), etc.

It is necessary to be clear that alpha frequency is associated with relaxed states of the brain and its value in the presence of positive images is lower in the left hemisphere than in the right. Positive images increase brain activity in the left hemisphere, as proposed by most of the studies consulted and according to Vecchiato et al. (2014) (Vecchiato et al., 2014).

4.2. Negative images

The median of the brain activity in terms of power of the right hemisphere is significantly higher than that of the left hemisphere in the alpha band with negative stimuli (avoidance). Which means that the right hemisphere has more power in the alpha band, therefore it is less active than the left.

The second hypothesis "In the ecological paradigm of electroencephalography, with negative stimuli (avoidance), the brain activity generated in the right hemisphere is greater than the brain activity generated in the left hemisphere" has been refuted. The differences of the brain activity in both hemispheres are significant differences, but do not stand in the way of the hypothesis.

A significant relationship was found between the brain activity of the right and left hemispheres and the valence evaluated by Castellar et al. (2001) for images of negative valence, although in the opposite direction to that initially expected. According to the authors consulted, it was expected that with negative images there would be greater activation in the right hemisphere, contrary to what was obtained experimentally.

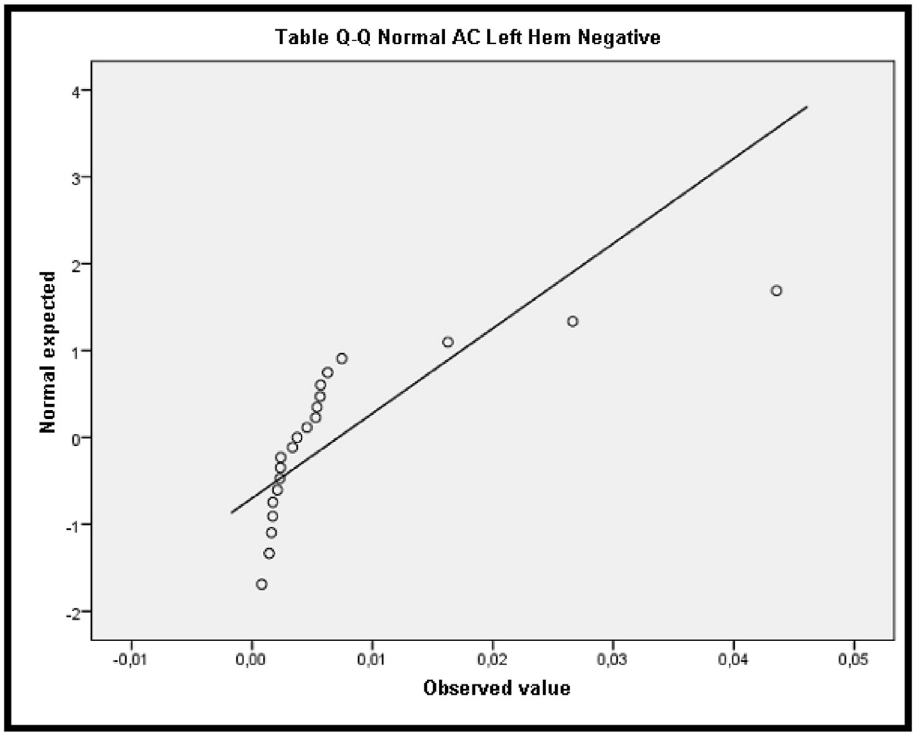

Fig. 8. Graphic of Normal expected/Observed value of the Brain Activity of the left hemisphere in the face of negative images (μV^2).

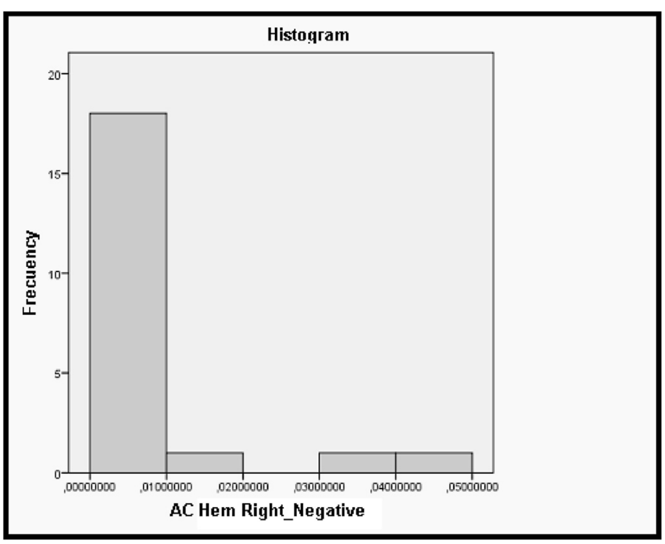

Fig. 9. Histogram of brain activity of the right hemisphere before negative images (μV^2).

It is necessary to be clear that alpha frequency is associated with relaxed states of the brain and its value in the presence of negative images is lower in the left hemisphere than in the right. Negative images increase brain activity in the left hemisphere against what was proposed by the authors consulted.

The images with negative valence have given opposite results to the expected one, maintaining a greater cerebral activation in the left hemisphere, although inferior to the cerebral activation caused with the positive images. This indicates that both when positive images are presented and when negative images are presented, the right hemisphere has a greater potency in alpha than the left hemisphere, which implies a greater brain activity linked to the processing of images in the left hemisphere than in the right in both cases.

However, the data indicate that the asymmetry is significantly greater for positive images than for negative images as is possible to check in the paper "Evaluation of the approach or avoidance for marketing actions images with neuromarketing. An ecological paradigm of electroencephalography" of the same author. The author has found that the cerebral activity of the right hemisphere minus the cerebral activity of the left hemisphere (in terms of potency) for positive images is significantly greater than the cerebral activity of the right hemisphere minus the cerebral activity of the left hemisphere for negative images:

(AC Hem Right_Positive - AC Hem Left_Positive > AC Hem Right_Negative- AC Hem Left_Negative), that aligns with that proposed by Vecchiato et al. (2014), Cherubino et al. (2015) and González-Morales (2018).

This means that both when it presents positive images and when it presents negative images the right hemisphere has a greater potency in alpha than the left hemisphere. This indicates a greater brain activity linked to the processing of images in the left hemisphere than the right in both cases, although it is necessary to specify that the asymmetry is significantly greater for positive images than for negative images.

Analyzing cerebral data of Table 1. The values of brain activity of each experimental subject registered in each hemisphere during the visualization of positive and negative images in μV^2, It can be seen how brain activity in terms of power of the right hemisphere is practically similar both for positive valence images (3.63 μV^2) and for negative valence images (3.62 μV^2). In the left hemisphere, there are greater differences between brain activity before positive valence images (3.01 μV^2) and those that cause negative valence (3.12 μV^2).

All authors consulted during the execution of this project have shown that there are differences between the brain activity of the hemispheres depending on the valence of the images with which the subjects are stimulated, as set out in the theoretical framework. All authors have confirmed the difference of brain activity on the prefrontal cortex between the left and right hemispheres, when individuals are stimulate with approach stimuli or with avoidance stimuli (Dolcos et al., 2004; Sutton & Davidson, 1997; Balconi et al., 2009; Harmon-Jones, 2003).

Some studies with EEG support the Valence Hypothesis, having found

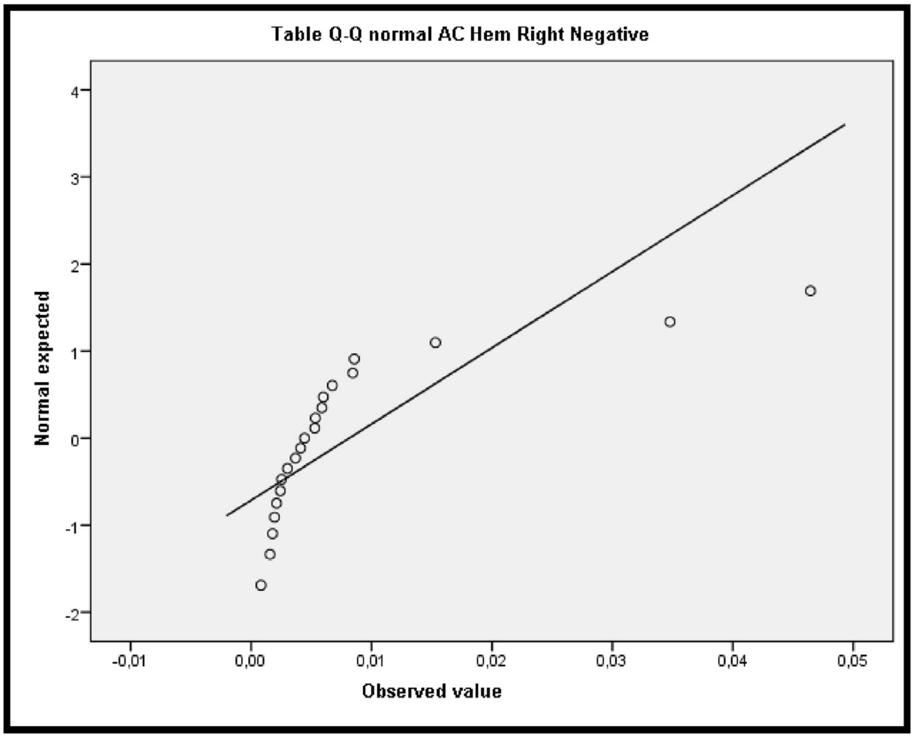

Fig. 10. Graphic Normal Expected/Observed Value of the brain activity of the right hemisphere before the negative images (μV^2).

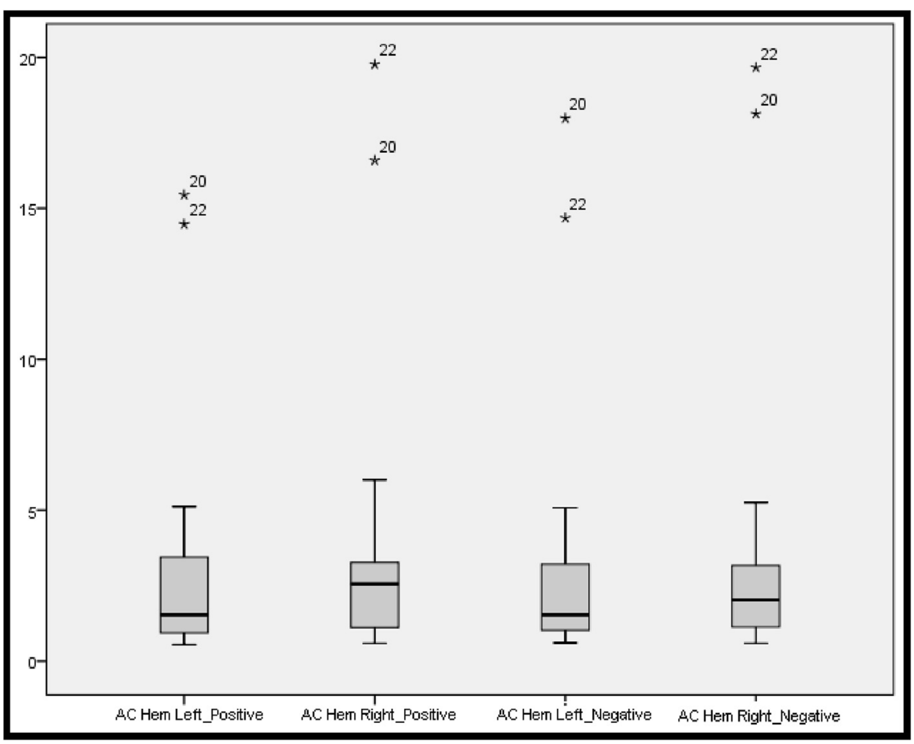

Fig. 11. Box diagrams of the variables: brain activity of the left hemisphere before positive images, brain activity of the right hemisphere before positive images, brain activity of the left hemisphere before negative images and brain activity of the right hemisphere before negative images.

higher levels of activity in the left hemisphere in the face of positive emotional states (Davidson & Henriques, 2000; Waldstein et al., 2000). Other studies with EEG have shown opposite results (Schellberg et al., 1993), in line with other results **which** found a specific frontal.

No one has carried out a study conducted with an ecological registration paradigm by electroencephalography in which the different

Table 4
Result of Wilcoxon signed-rank test.

	AC Hem Right_Positive - AC Hem Left_Positive	AC Hem Right_Negative - AC Hem Left_Negative
Z	−2.312[b]	−2.038[b]
Sig. asintót. (bilateral)	.021	.042

[b] Based on the negative ranges.

patterns of brain activity have been compared with images previously evaluated in a scientific way with positive valence[3] (focus) and with negative valence (avoidance), separately. Herein lies the uniqueness of this project.

5. Conclusions

With this work the main objective of the research has been achieved. The two hypotheses raised have been investigated.

We are able to conclude that with the collected data, through the instruments used, with the individuals selected in the sample, with the sample size, under the conditions of execution, by means of the method and procedure followed, using the selected images and with the existing limitations, the following:

The Hypothesis 1 has been confirmed. We must accept null hypothesis (H_0): In the ecological paradigm of electroencephalography, with positive stimuli (approach), the brain activity generated in the left hemisphere is greater than the brain activity generated in the right hemisphere.

The Hypothesis 2 has been rejected. We must reject the null hypothesis (H_0): In the ecological paradigm of electroencephalography, with negative stimuli (avoidance), the brain activity generated in the right hemisphere is greater than the brain activity generated in the left hemisphere". We must accept the alternative hypothesis (H_1): In the ecological paradigm of electroencephalography, with negative stimuli (avoidance), the brain activity generated in the right hemisphere is not greater than the brain activity generated in the left hemisphere. There is a significant difference between the brain activities between both hemispheres for negative valence stimuli, but in a different direction from that expected according to the second hypothesis.

With this knowledge, it is possible to evaluate with an ecological electroencephalography methodology (valid for evaluating dynamic stimuli), if the marketing stimuli are adequate or inadequate to build the appropriate footprint in the memory of potential clients and create a perception of approach that can influence their future purchases. The consulted authors point out that a positive valence in marketing stimuli help to create a footprint in the memory and perception of approach to brands and companies.

6. Limitations and future research

The sample size has been limited to 23 participants, a size that falls within the usual range of this type of experiment, but it may be desirable to replicate the experiment so that the conclusions can be extrapolated to the general population with greater robustness.

One could study whether there is a relationship between the patterns of brain activity and the memorization of images, both in the medium and long term.

The data obtained from the Brain Activity by electroencephalography of seven individuals had to be discarded for the experiment, due to not having been able to establish the adequate synchronization, finding an excess level of artefacts or due to the production of errors in the files during the multiple phases of the treatment of the data with the EEGlab software. Therefore, the study of the Brain Activity variable was carried out with data from 23 individuals.

[3] In this work, a questionnaire has not been used, since the images had been evaluated in abroad and scientific way in terms of their valence by experts in this field.

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