

**DEVELOPING A CONCEPTUAL FRAMEWORK FOR NEUROIMAGING APPLIED TO  
NEUROMARKETING: An Integrative Review of Literature**

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## **Abstract**

Neuromarketing is a growing approach to research that has gained attention among marketing researchers. Specifically, neuroimaging tools are among the most used tools in neuromarketing, as it provides a three-dimensional view of the brain with coordinates denoting areas of the brain. However, the literature in this area is very dispersed, with no identification of what each area of the brain represents for neuromarketing and consumer behaviour. Therefore, the study carried out a systematic review of the literature, followed by the integration of the data into a conceptual framework, demonstrating the main themes studied in neuromarketing and which areas are activated in the brain for each of these themes. The themes identified were: decision making; attention, emotion and reward; brand recognition; preference; attitude; memory. It was identified challenges that future researches should address and suggestions for future research are also raised.

**Keywords:** Neuromarketing; Neuroimaging; Systematic Literature Review.

## **1. INTRODUCTION**

Neuromarketing, or consumer neuroscience, is a growing research approach that has gained increasing attention among marketing researchers and consumer behaviour. This approach allows a different or complementary alternative for marketing researches, since most marketing researches uses self-reported data, which may present biases. Therefore, neuromarketing is a viable research alternative, allowing to deep the understanding of the cognitive processes and the mechanisms that explain the behaviour of the consumer (LIN et al, 2018).

In the last decade, there was a significant increase in neuromarketing research in marketing and consumer behaviour journals, and in the year of 2015, Journal of Marketing Research published a special edition exclusively devoted to neuromarketing research. Based on this scenario, some researchers have suggested the importance and benefits that integrative literature review studies in this area can generate (LEE; CHAMBERLAIN; BRANDES, 2018; LIM, 2018).

Santos et al (2015) has already carried out a review of the literature, selecting a specific tool of this research area, specifically the eye tracking, and identified the state of the art of studies that utilize this tool, as well as the importance of the tool for neuromarketing. The authors further suggest that these reviews can be made using other tools common to neuromarketing, identifying the importance of these to improve the knowledge of consumer behaviour.

According to Lim (2018), neuromarketing literature review researches maps the current state and contributions of existing literature, allowing future directions to be identified for further research in this area. Specifically, the author points out that the functional magnetic resonance (fMRI) tool is one of the most used in neuromarketing because it provides a three-dimensional view of the brain with coordinates denoting the areas of the brain. These areas can be identified and correlated with specific behaviours of the individual. Although these researches have demonstrated the development of understanding of consumer's subconscious behaviour, the decision-making models and unconscious choices in the context of neuromarketing have not been fully delineated (DOBORJEH et al, 2018). That

is, researches are much dispersed, and it is difficult to understand the relation between certain areas of the brain with the behaviour of the individuals.

Based on this context briefly presented, the following problem emerges: What are the main areas in the brain studied in neuromarketing? The objective of this article is to identify the areas of the brain most used in neuromarketing and what they represent for this topic. The systematic review of the literature is justified by synthesizing the main contributions of these researches, identifying the main areas of the brain used and their representativeness for neuromarketing. Among the neuroimaging tools to identify the most traditionally used areas of the brain that will be searched are fMRI, the functional near-infrared spectroscopy (fNIRS) and high resolution electroencephalogram (HR-EEG).

At first, an introduction will be made to the concepts of neuromarketing and neuroimaging tools, in the context of consumer behaviour. Then the methodology of the study will be presented, followed by a systematic review of the literature and the integration of the data surveyed. Finally, the final considerations were made, identifying possible suggestions for future research.

## **2. NEUROMARKETING**

The term neuromarketing first appeared in a scientific paper title by Lee (2007), which dealt with neuroimaging techniques being applied to marketing research, and the advances that this could bring to the area. Relevant marketing topics have already appeared in some previous studies of neuroeconomics and neuroscientific literature.

Neuroscience applied to consumer behaviour uses neuroscientific tools and theories to better understand the cognitive processes that lead the consumer to make a decision, to take an attitude or some other process related to the behaviour. They are tools and theories that help to deepen the understanding of the cognitive processes, as well as the underlying mechanisms that help to explain the behaviours of the consumers (PLASSMANN et al, 2015; YIN et al, 2017).

Neuromarketing has many specifics and nuances, besides being a multidisciplinary area of study, so its definition shows itself to be somewhat complex. In this sense, Oliveira and Giraldi (2017) make an analysis of the definitions of the term used so that they could develop a broader definition that would attend to the various nuances of this discipline. The definition given by the authors was:

Neuromarketing is an interdisciplinary field of science that uses various tools traditionally used in medicine, psychiatry and psychology on neurofeedback, biofeedback and metabolic processes measures, in conjunction with traditional marketing tools in the search to better understand the most diverse types of emotions, cognitions, physiological reactions, behaviours and thoughts of economic agents, both conscious and unconscious related to typical issues of Marketing and its various sub-areas (OLIVEIRA; GIRALDI, 2017).

According to Lin et al (2018), researchers already recognize that self-reported questionnaires and interviews, although fundamental to marketing studies, have deficiencies, especially regarding biases of this type of measurement tool. Neuromarketing would then be a methodological alternative to overcome such difficulty.

Oliveira and Giraldi (2017) sought to organize the measurement methods used in neuromarketing in two distinct categories, these being neurofeedback and biofeedback. According to Sitaram et al (2016), neurofeedback is a psychophysiological procedure in which online feedback of neural activation is provided to the participant for self-regulation purposes. Neurofeedback has provided a new way to investigate brain functions by

controlling specific neural substrates, demonstrating that it is then possible to control some specific behaviour.

In biofeedback, Gartha (1976) defines it as any technique that uses instrumentation to provide momentary information of a person about a specific physiological process that is under the control of the autonomic nervous system, but is not perceived with clarity or precision.

In view of these two categories, the table below summarizes the categories of measurement techniques in neuromarketing and what exactly is measured and analysed in each category.

**Table 1.** Categories of Measurement Techniques

	Measurement Category	What is measured / analyzed
<b>Neuromarketing</b>	Neurofeedback	<ul style="list-style-type: none"> <li>- Metabolic brain responses</li> <li>- Electrical / magnetic brain activities</li> </ul>
	Biofeedback	<ul style="list-style-type: none"> <li>- Eye movement and dilation</li> <li>- Electrical conductance of the skin</li> <li>- Heart beats</li> <li>- Body temperature</li> <li>- Energy expenditure</li> <li>- Facial movements</li> <li>- Hormones/Neurontransmitters</li> <li>- Other responses</li> </ul>

Source: Oliveira and Giraldi (2017).

For Oliveira and Giraldi (2017), the use of these tools in marketing research is an important complement to the traditional methods, so that new perceptions of consumer behaviour can be evidenced. With each new discovery of the human brain and what are the subsequent effects on the body, these new findings will impact future studies in the field of marketing.

Specifically, this study will investigate the use of neuroimaging tools in articles on consumer behaviour. The neuroimaging measures and maps the brain activity by detecting changes in blood flow in the brain region. In this method, considered as non-invasive, it is possible to have a three-dimensional view of the brain with coordinates denoting areas of the brain activated from the stimuli performed (LIM, 2018).

In neuromarketing researches, the subject of the test is exposed to a marketing stimulus, and certain areas of the brain will receive more oxygenated blood flow than normal. This activity can be measured using fMRI or fNIRS (LEE; CHAMBERLAIN; BRANDES, 2018). High resolution EEG, although it is not a neuroimaging tool, has good spatial resolution, allowing the detection of brain activities and cerebral connectivity on the cortical surface with a spatial resolution of one square centimetre (ASTOLFI et al, 2008). The next section will address the methodological aspects for conducting this research.

### 3. METHODOLOGY

The systematic review of the literature allows the development of new theories or new paths for the identification of knowledge gaps to be solved in the future (WEBSTER; WATSON, 2002). These systematic and integrative reviews are a particular form of research that reviews, critiques, and synthesizes representative literature on a given topic in an integrated way, so that new structures and perspectives on the topic are generated (TORRACO, 2005). This article, therefore, was structured in two stages. At first, a systematic

review of the literature was carried out; the second one is the integration of the data collected in a conceptual framework.

In the systematic review stage, in order to remove the subjectivity of this search, specific algorithms were pre-determined. These algorithms are: (i) database; (ii) keywords; (iii) filters; (iv) article retention criteria. In a first moment, the databases were selected, these being: *Scopus*, *Web of Science*, *Springer Link*, *Wiley Online Library*, *Sciverse Science Direct* and *Sage*. The choice for these bases is due to the fact that they publish peer-reviewed scientific articles and are recognized in the international scientific community, they also have a focus on academic production in areas associated with applied social sciences.

In order to find articles that identify the main areas of the brain most traditionally used in neuromarketing, these terms were used: “*neuromarketing*”; “*neuromarketing*” AND “*fMRI*”; “*neuromarketing*” AND “*fNIRS*”; “*neuromarketing*” AND “*hr-eeG*”. High resolution EEG was investigated due to the fact that it had a higher spatial resolution in relation to the common EEG (ASTOLFI et al, 2008).

The filters were applied with the purpose of refining the research, being considered in this review only scientific articles, in English language and that was aligned with the area of applied social sciences. The criteria for article retention were that the article should use some neuromarketing tool to identify specific brain regions and relate them to a given behaviour. Among the tools used are fMRI, high resolution EEG and fNIRS.

From the identified articles, the abstracts, the excerpts specifying which area of the brain is being worked on and the results were read. This method of literature review allows to identify the main themes and ideas to be analysed and later integrated into the conceptual framework.

## **4. SYSTEMATIC REVIEW OF LITERATURE**

### **4.1 Decision Making**

Recent advances in cognitive neuroscience are unravelling the neurological bases of cognitive, emotional, and social processes. These advances allow a new perspective on information processing, decision making and behaviour among consumers, organizations and markets. In particular, decision making is a process in which the individual makes a choice based on the gathering of information about a determined theme and the evaluation of the alternative resolutions (CASADO-ARANDA et al, 2018).

fMRI is used in these studies to identify the consumer's brain reactions during visualization and perception of stimuli in the decision-making process (MUÑOZ-LEIVA; GÓMEZ-CARMONA, 2019). Brain activity is measured under different contexts and different themes in decision-making studies.

Kühn, Strelow, and Gallinat (2016), for example, have studied the decision to purchase chocolates directly at the point of sale, and which areas of the brain are activated that affects this buying decision process. According to the authors, the main activated areas are the frontal region of the gyrus and the ventral striatum. Areas such as the prefrontal cortex and the insula have a negative impact on the decision-making process.

Lee and Yun (2019) analyses the time constraint that the consumer often faces at the moment of decision making. According to the authors, time restriction can lead to increased mental efforts by altering the outcome of the judgment at the time of the decision. The main area identified and studied was the prefrontal cortex, and increased activity in this area would represent increased mental effort due to time constraints.

Still in the context of decision making, Berns and Moore (2011) used neuroimaging to predict cultural popularity, specifically regarding music's theme. The results identified by the

authors suggest that neural responses are predictive of buying decisions for the individuals studied, and it is also possible to generalize these responses to the general population. In the study, increased ventral striatum and nucleus accumbens activity assists in the prediction of consumption of certain popular songs, the increase in these areas would mean greater consumption by the individuals studied.

Another neuroimaging research involving decision making is that of Reimann et al (2010). In this research it was identified that the packaging aesthetics significantly increase the reaction time of the consumer responses. Packagings considered aesthetically pleasing are chosen at the expense of products with well-known brands. This is a result of the greater activation in the nucleus accumbens (present in the ventral striatum) and in the prefrontal cortex, identified from the fMRI tool.

Regarding cognitive behaviour of decision making, several subtopics and different contexts can be studied using tools capable of detecting responses of brain activity, according to the data collected for this review. Such studies advance in decision-making behaviour using neuromarketing techniques. Although the main tool used was fMRI, others were also used as high resolution EEG (KOLEV, 2019) and fNIRS (LEE; YUN, 2019).

## **4.2 Attention, Emotion and Reward**

The sensory capacities of human beings, such as vision and hearing, allow for a greater concentration of the individual on certain objects that generates the stimulus. This stimulus can often generate some kind of emotion, further strengthening the individual's engagement in this stimulus (SHI et al, 2017; MORRIS et al, 2009). Studies using some neuroimaging tool allow a better understanding of the behaviour of the consumer, from these brain images.

According to Nishida and Nishimoto (2018) the experience of perception in film scenes activates some areas of the brain that generate more attention. The authors identified perceptions induced by objects, actions and impressions in the form of words, and how this influences individual's brain activity and their respective perception. The areas activated in this study were the gyrus, especially the fusiform, and the superior temporal sulcus. These areas are responsible to the increasing attention of the individuals, according to the authors.

Concerning emotion, Shen and Morris (2016) studied consumer's emotional responses to watching television commercials. The importance of three main dimensions of emotion was indicated: the appeal, the engagement and the empowerment. In particular the appeal and the engagement are capable of generating positive attitudes on the consumers towards the television commercials. The activated regions were the frontal and parietal part of the gyrus, as well as the upper part of the parietal lobe.

In another article, Morris et al (2009), rather than studying functional neuroimaging through the relation between the activation of one area of the brain and a given behaviour, the author investigates the brain regions to validate a three-dimensional construct, those being pleasure, excitement and dominance. The findings provide a better understanding of human behaviour in response to advertising stimuli. The activated regions refer to the frontal and parietal part of the gyrus.

When it comes to the reward factor, it has an involvement with the processing of emotions. It is possible to relate brain activities related to emotions and reward with behavioural preferences of consumers (KÜHN; STRELOW; GALLINAT, 2016). According to Chen et al (2017), the regions of the brain triggered in reward processing refer to the ventral striatum and prefrontal cortex.

Jung et al (2018) article, for example, studies the appeal of celebrity use in television commercials, and how this affects consumer behaviour. For the authors, there is a positive

association between the celebrity and the product being divulged. One possible explanation for this is that a celebrity's face can serve as a reinforcing stimulus, which results in the transfer of the reward by seeing this celebrity to the product being divulged. The brain areas activated was the left orbitofrontal cortex and left anterior insula. It was found that the scores of the products being divulged were positively correlated with the neural activity on these areas.

### **4.3 Brand Recognition**

Attributes and characteristics related to a brand can alter the judgment of the consumer on the product offered and it is important to identify the physiological aspects of how brands are processed in the consumer's brain to identify possible determinants of what makes a brand "better" or more recognized (HILLENBRAND et al, 2013).

Meyerding and Mehlhose (2018) used fNIRS in the context of brand design and package design to identify brand recognition in food products. The different influences of strong and weak brand labels in a food related context were analysed. According to the authors, when individuals consume products of known brands they generate a significant increase in the activation of the prefrontal cortex in comparison with other smaller brands.

In the paper by Plassmann, Ramsøy and Milosavljevic (2012), the authors argues that neuroscience can advance the understanding of consumer psychology with regard to brands. Areas related to the prefrontal cortex, cingulate gyrus and nucleus accumbens are identified in studies related to the brand, especially those that generate greater recognition, pleasure or attention of the consumer.

Plassmann et al (2008) identified that ambiguity of choice modulates activity in brain areas that represent preference for a particular brand. That is, different brands, presenting very similar products can cause consumers to process this information differently, in a brain level, changing their purchase. The findings reveal that the brain areas involved in the interaction of brand information and ambiguity information are the ventromedial prefrontal cortex and the anterior cingulate. The same patterns of activation were found previously to correlate with brand preference, according to the authors.

Another type of study related to the brand was made by Fehse et al (2017). In a context of organic products, the authors aimed at the neural correlates of perceptions of two types of aggregate psychological value that brands could provide, these being popular and organic. The results indicated a greater activation in the medial prefrontal cortex for the popular brands and a greater activation in dorsolateral parts of the prefrontal cortex for the organic ones. These studies demonstrate some of the contexts that use neuroimaging to gain insight into consumer behaviour.

### **4.4 Preference**

Many organizations often invest heavily in marketing strategies to build loyalty and preference among consumers. Accurately estimate the subjective preference of consumers for a particular product using neuroimaging methods is an important area in neuromarketing, and such an approach can be used to establish product design and marketing strategies (KIM et al, 2016).

According to Bruce et al (2012), brand has a significant effect on familiarity and preference for products, and it is important to analyse the neural responses to the logos, while the consumers observes it. This study examines children's brain responses to advertising stimuli. According to the authors, the brain areas activated in logos considered preferred by the children were the prefrontal cortex and cingulate cortex.

Santos et al (2011) also studies brain activity in the context of preference over a particular brand. It is evidenced in the study that the prefrontal cortex seems to be involved in the preference of a determined brand, however, the authors points that this process only occurs after the purchase of this particular brand. According to the authors, the preference of a brand is bigger after the individual buy the product, increasing the activity in the prefrontal cortex.

In another paper, Wolfe et al (2016) investigated whether or not there were differences in brain activity for unfamiliar and familiar foods, leading to a better understanding of consumer's preference for food using fMRI. The results indicate that unfamiliar food showed significant activation in the parietal lobe and insula areas, as unfamiliar foods had more activation in the prefrontal areas of the brain.

#### **4.5 Attitude**

Attitude can be defined as a subjective predisposition that will lead to certain behaviour. The attitude generated about a given object or behaviour can be positive or negative, and the more favourable the attitude, the greater is the intention of the person to perform the behaviour in question (AJZEN, 2002). Neuromarketing studies emerge investigating the brain activity of consumers to understand the attitude of the individual to a particular brand or product.

Attitude was studied in an article by Hsu and Cheng (2018) when examining whether gender influences brain activation associated with negative word-of-mouth (WOM) communications. The major areas activated by fMRI in women showed significant positive brain activity in the calcarine sulcus and the insula lobe, meaning that women shows more negative reactions to negative WOM, but no effect in men was found.

Another article deals with this theme by investigating the factors that support the consumer's attitude toward switching from one brand to another. Al-Kwif (2016) argues that there is a lack of understanding of the importance of assessing brain activations in consumer attitudes towards brands. The main area activated in this study was the ventromedial prefrontal cortex. According to the authors, the higher the perceived usefulness of a particular brand product, the greater the activation of the ventromedial prefrontal cortex during decision-making to switch to other products.

Still dealing with attitude, Hedgcock, Vohs and Rao (2012) studied self-control using fMRI. For the authors, the exercise of self-control is a crucial element of human behaviour, particularly with regard to consumption, and it is fundamental to identify areas of the brain related to this particular behaviour. Among the brain areas identified in the study are the frontal gyrus and anterior cingulate. The diminishing in the activity of these areas means that the consumer regulatory resources were diminished during the choice task, so the consumers have less self-control when this activity in these areas diminishes.

#### **4.6 Memory**

In purchase decision processes that are repeated over time, the purchase of a particular brand becomes a process of low involvement, and it also becomes automated and habitual. Much of the advertising content is not consciously processed, so these perceptions caused by the stimulus of an advertisement are stored in the consumer's memory (MCDONALD, 2003).

Memory, therefore, is also explored in neuromarketing studies. Astolfi et al (2008) investigate, for example, brain activity during the observation of television commercials, in order to elucidate the commercials that were remembered by the subjects several days after their first observation. These commercials elicited different brain activity compared to those



generated while observing commercials that were quickly forgotten. With the use of a high resolution EEG, it was identified that some of the regions of the Brodmann area are activated in the most remembered commercials, these areas being frontal (8 and 9) and parietal (5,7 and 40).

Jung et al (2018), in an article about the use of celebrities in advertisements, showed that neural activity in brain areas associated with memory was higher when the advertisement was associated with a celebrity face. Among the identified areas associated with memory are the orbitofrontal cortex, the insula and the occipital lobe.

In analysing adolescent behavioural and neural responses to electronic cigarette advertising, Chen et al (2017) found that these advertisements showed significantly greater brain activation in areas associated with memory, especially the hippocampus, while individuals were viewing electronic cigarette advertisements. These studies show, therefore, that memory ends up being an explored topic in the area of neuromarketing, being used to further deepen the knowledge of consumer behaviour.

## 5. DATA INTEGRATION

The integrative literature review is a form of research capable of generating new knowledge about the reviewed theme. This review, in addition to illustrating the current state of the art, allows new relationships and perspectives to emerge, as well as identifying challenges of neuromarketing studies to be solved in future researches (TORRACO, 2005).

In order to integrate the information collected through the systematic review of the literature, a conceptual framework was elaborated of the areas of the brain most traditionally used in neuromarketing, relating these to the main themes found in these studies. Table 2 presents this conceptual framework.

**Table 2 - Conceptual Framework.**

<b>Themes</b>	<b>Importance to Neuromarketing</b>	<b>Activated Brain Areas</b>
Decision Making	Sales Prediction	Prefrontal Cortex Frontal Lobe Superior Frontal Gyrus Medial Frontal Gyrus Inferior Frontal Gyrus Ventral Striatum
	Purchase Prediction	
	Intention of Use	
	Reaction Time for Decisions	
	Intention of Purchase Observing Style of Celebrities	
	Time Restriction for Decision	
Attention, Emotion and Reward	Cognitive Control, Reward, Visual Processing and Attention.	Precentral Gyrus Superior Frontal Gyrus Medial Frontal Gyrus Inferior Frontal Gyrus Cingulate Gyrus Parietal Lobe Ventral Striatum Insula
	Products Used by Celebrities	
	Emotions Caused by Commercials	
	Perception Experience	
	Television Commercial Appeal	
	Attention to Advertising and Promotions	
	Response to Vocal Stimulus in Advertising	

Brand Recognition	Brand Evaluation	Temporal Lobe
	New Brands in Relation to Well-Known Brands	Parietal Lobe
	Brand Choices	Fusiform Gyrus
	Impression of a Brand	Prefrontal Cortex
	Choice of Brands with Ambiguous Information	Cingulate Gyrus
	Brands vs Organic	Nucleus Accumbens
Preference	Subjective Preference of Consumers	Prefrontal Cortex
	Familiar and Unfamiliar Foods	Orbitofrontal Cortex
	Recognition	Cingulate Cortex
	Preference for Common or Brand Foods for Children	Occipital Lobe
	Preference About Certain Brands	Insula
Attitude	Self Control	Medial Frontal Gyrus
	Positive or Negative Word of Mouth	Calcarine Sulcus
	Product Replacement	Anterior Cingulate Cortex
	Trust or Distrust	
Memory	Memory Regarding Television Commercials	Prefrontal Cortex
	Memory and Attention to Celebrities	Orbitofrontal Cortex
	Brand Memorization and Positioning	Amygdala Hippocampus

Source: Elaborated by the Author (2019).

This conceptual framework synthesizes some of the main marketing themes studied from the perspective of neuroscience, identified from the literature. For each of these themes, the research topics that are important for neuroromarketing have been identified, especially those that contribute to a deeper understanding of consumer behaviour. Based on the studies conducted through the systematic review of the literature, the main brain areas activated for their respective themes were also listed.

Although neuroromarketing is a field of research that has gained attention and relevance among marketing researchers, it also has some challenges that new researchers should be aware of when conducting their research. One of these key challenges identified is the fact that this type of research primarily informs about the consumer's brain, not the consumer's behaviour. This can occur when the study reaches a result that has statistical significance, but in fact the result happened by chance, occurring a false positive call (PLASSMANN et al, 2015). Therefore, caution is needed to make claims that a certain area of the brain is a cause for a particular behaviour.

However, Bennett, Wolford and Miller (2009) argue that to avoid this type of problem in neuroscientific research, some techniques can be used during statistical analysis, such as the Bonferroni procedure for the statistical analyses performed, thus avoiding the post hoc and false positive problems. This precaution was used by Ohme et al (2010) and Shen et al (2018) in their neuromarketing studies, but many other studies did not mention this challenge, leading to the risk of false positives.

Another identified challenge refers to the choice of the method and the tool used in the study. Looking at the revised empirical literature, few studies provide an explanation of why neuroimaging is being used, and also why a specific method itself should be used, to the detriment of other methods. It is a similar problem that Lee, Chamberlain and Brandes (2018) have identified in their review regarding neuroromarketing. It is fundamental that these studies make it clear the reasons for the choices of their equipment and methods, as this makes the

study more transparent and demonstrates the researcher's awareness of the appropriateness of the best possible method to be used to achieve their objectives.

## **6. FINAL REMARKS**

Based on the above discussions, it was possible to identify the main topics studied in neuromarketing and how they use techniques of neuroimaging to deepen their understanding of consumer behaviour. In this analysis, the main areas of the brain activated under the specific study contexts of each theme were identified. The article showed the potential of tools such as fMRI, fNIRS or high resolution EEG for the development of general marketing research. The use of these techniques, as well as the identification of the main contexts in which they are used, demonstrates the potential of the same also for market planning and strategies. Therefore, the problem of this studied was addressed, with the conceptual framework, indicating the main areas of the brain activated in neuromarketing studies. The objective of this article was achieved, being that the most important topics studied in neuromarketing were identified, as well as the brain areas activated for each of these themes.

Future research can investigate topics related to the market, consumer behaviour, advertising, innovation, sales or post-purchase process. These topics allow an advance in the understanding of the consumer with respect to their behaviour in the face of a market stimulus. According to the systematic review of the literature, certain activities in specific regions of the brain may help in developing the understanding a particular behaviour. These studies allow the advancement both in the academic field of marketing and in the managerial field, and the organizations can use this information for market situations as well.

The study also contributes to the improvement of future neuromarketing researches, identifying some problems and challenges in the current literature. There are few studies that provide an explanation of why neuroimaging is used and why a specific method is used to the detriment of other methods. Another challenge refers to the risk of false positive, where a null hypothesis is rejected when it might be actually true. According to the literature this occurs because of the difficulty to correlate a certain area of the brain with certain behaviour of the individual. However, this can be avoided by using the Bonferroni process. Future neuromarketing studies may address these issues in order to improve research in this area.

This article has some limitations, since it is a systematic review of the literature. It does not produce, for example, data or empirical analysis. However, efforts have been made to produce an objective view of the state of the art of neuromarketing studies using neuroimaging tools, as well as to identify the main areas of the brain activated and their relevance to this area of study. Another limitation refers to the fact that they were only considered articles in English, making it impossible to verify the panorama of the studies on this subject in the context of the publications in other languages or databases. When conducting the filtering process, it is possible that relevant researches have been omitted from this analysis. However, the rigorous procedure in the systematic review of the literature reduces the possibility that possible omitted research would demonstrate information that would greatly alter the outlook and trends for future research on this topic.

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