A Review of Research on Neuromarketing Using Content Analysis: Key Approaches and New Avenues

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Abstract

There is currently a growing interest in a deeper understanding of consumer behaviour. In this context, the union of different disciplines such as neuroscience and marketing has given birth to new fields of knowledge, e.g. neuromarketing. This study is mainly aimed at carrying out a systematic revision of the literature on neuromarketing from a holistic point of view, analysing its definition and processes, as well as more specific aspects such as its ethics and applications. Based on the results of our review, following a combined methodology with a base dictionary and text mining, our study presents both the current lines of research and the future lines of work.

Keywords

Neuromarketing; Consumer Neuroscience;Text Mining; Dictionary; Qda-Miner; Wordstat

Introduction

In the last decade, researchers have become increasingly interested in neuromarketing (Lee, Chamberlains and Brandes 2018). Neuromarketing is defined as the application of neuroscientific techniques (specialised in cognitive research) to the field of marketing (Cruz et al. 2016; Lee et al. 2017, 2018). This discipline aims to establish a sound neuropsychological theory that allows people to understand consumer behaviour by combining adapted neuroscientific methods, behaviour theories, experimental models and designs accepted by consumer psychology (Plassmann et al. 2012). In addition, by measuring the brain's processes, this new discipline provides a wider understanding of consumer reactions to marketing stimuli (Bakardjieva and Kimmel, 2017). This is the reason for the discipline's multidisciplinary nature, derived from the union of neuroscience, psychology and marketing (Cruz et al. 2016).

It is precisely the multidisciplinary nature of neuromarketing that inspired great enthusiasm both to academic researchers and large companies specialised in marketing in the last few years (Plassmann et al. 2015). The enthusiasm among researchers has significantly increased the number of studies using neuroscientific methods published in marketing magazines. Additionally, the growing interest in neuromarketing has produced a proportional growth in the number of academics whose research is based on this field (Lee et al. 2018).

The growing interest in neuromarketing by academics coming from different areas of knowledge such as neuroscience and marketing has given way to a great dispersion among the different publications (Lee et al. 2018). The need to have academics from different fields of research in this new discipline is due to the multidisciplinary nature of the experiments carried out. This is why a large number of articles focussing on neuromarketing are disseminated across many different magazines on very diverse topics.

In view of the above, this study carried out a systematic revision of the literature based on a holistic and comprehensive approach to identify different lines of research under this field of study, by addressing not only its definition and the research techniques applied, but also other aspects such as the ethics governing its practices and its applications. Achieving this goal can provide the theoretical basis for studies by other researchers, as well as a useful help tool to choose works, magazines and authors that may be considered important in each of the lines of research identified.

To carry out this revision, a methodological proposal for automated text processing was designed. In view of the multidisciplinary nature of neuromarketing, it is advisable to follow a two-stage process to improve the accuracy and reliability of the analysis. The first stage of the proposal consists of creating a basic dictionary created semi-automatically. This will serve as a pre-processing step for the second stage, which consists of text mining. The second stage also involves interpreting the groups derived from the text mining step, which are the current lines of research in the field of neuromarketing. This study will conclude by suggesting several future lines of research.

In the following sections an in-depth explanation will be provided on the methodological proposal and its application to neuromarketing.

A methodological proposal based on text mining

Text mining is an innovative technology which extracts essential information from non-structured text data. To that end, text mining looks for usefulness models, patterns or rules of apparently non-structured data (He, Zha and Li, 2013). This technology has the same foundations as data mining, adapted to the analysis of bodies of text data, in order to extract knowledge from them (Kumar and Ravi, 2016). The text mining process is made of three stages: (1) text pre-processing; (2) text processing and analysis; and (3) viewing and interpreting the results obtained (He et al. 2013).

The first stage is essential for the process and it involves transforming the documents to be analysed in a data structure that can be automatically read and processed to draw key concepts and provide a preliminary idea of the contents (He et al. 2013; Kumar and Ravi 2016). Taking Guerreiro, Rita and Trigueiros (2016) as a reference, the process involves the following steps: (1) the format of the texts is erased by converting it into plain text and dividing the texts into tokens (individual words); (2) stop words (i.e. words without a proper meaning such as prepositions, adverbs, etc.), as well as punctuation marks and/or numbers are filtered and eliminated; and (3) non-discriminatory words (i.e. words commonly used in scientific research such as 'authors,' 'hypothesis,' 'study,' among others) are also eliminated.

The second stage involves processing and analysing the texts. To that end, specific text mining algorithms are used (they will vary depending on the programmer), which identify and classify trends about the previously generated data structures based on the frequency of use of similar terms. Afterwards, the algorithm classifies the documents into groups established according to the terminology shared across the texts. Consequently, the groups are created when the most usual terms are associated and classified under a common topic (Natarajan 2005; Guerreiro et al. 2016; Romero-Domínguez et al. 2019).

In the third and last stage, focused on viewing and interpreting the results obtained, the researcher establishes the relationship among the documents included in the same group and evaluates them, inciting discussion and recognising future lines of research based on the results (He et al. 2013; Romero-Domínguez et al. 2019).

Text mining comes from the imperious need to automatically collect useful information from a large number of texts/documents. That is why, as an automated technique, text mining can be used for several tasks such as identifying, collecting and managing information in the texts in an efficient, systematic way, as well as integrating and exploring the knowledge provided by different texts/documents (He et al. 2013). It becomes a highly useful tool for researchers therefore, in reviewing the initial literature because they can obtain information about the shared terms across a large number of texts and establish groups to more easily understand a specific subject matter (He et al. 2013). However, this technique can be problematic when the subject is too generalised or the area of search is too broad. In these cases, the algorithms become less sensitive, making the study fail due to term dispersion (lack of clarity) and the abundance of residue (non-focused, unspecific topics) (Guerreiro et al. 2016).

As an answer to the issues related to text mining in multidisciplinary research topics, where the field is quite broad, it becomes necessary to improve the technique. Some authors - although very few - address these problems and try to provide solutions that improve the accuracy of text analysis by means of different pre-processing techniques. Among those authors we should highlight the studies made by Basaldella et al. (2016, 2017) in the field of biomedicine. The authors combined two techniques to identify categories within texts: dictionary and machine learning. They started by using the former to recognize explicit categories. This technique is based in an automatic process to detect all the words in a document matching one or more dictionaries extracted from the literature on the research topic. The inconvenience of this method is that new categories are not present in the existing dictionaries, which is why it should be used in combination with another technique. The second technique used by Basaldella et al. (2016, 2017), i.e. machine learning, involves using part of the texts in the database on the research topic to train the algorithm. It will thus be able to recognise texts related to that topic. Next, using the remaining database, tokens (separate words in each text that has not been used in the machine learning process) are classified into the categories included in the dictionary. The inconvenience of this technique resides in the fact that the texts used for the training

process are left out of the study. According to the authors, using both techniques offered highly reliable results by making use of their strengths and diminishing their weaknesses.

Moro et al. (2019) followed an alternative procedure in their research on ethnic marketing. The authors used two dictionaries (a 'sufficient' dictionary and a 'conditional' one) to build the final corpus of documents on ethnic marketing that would subsequently be analysed and synthesised by means of text mining. The two dictionaries, which were conceived to review the contents of the chosen articles in depth, were written manually by the researchers. The 'sufficient' dictionary collected the terms that appeared often enough in the document for it to be identified as belonging to the field of ethnic marketing. On the other hand, the 'conditional' dictionary includes a larger number of terms (cultural group, minority, etc.) that seem related to the research topic, but may or may not be actually related to ethnic marketing. Consequently, the decision to include or exclude the documents identified with this dictionary depends on whether a term included in the 'sufficient' dictionary is identified. The authors support the use of dictionaries on the research topic because understanding the context is essential to ensure that text processing systems produce appropriate results. Additionally, they advocate for including them in the process to improve the precision of such systems; however, they also stress the need to search for the most objective dictionaries available to avoid subjectivity in their constructs (Moro et al. 2019). The method developed by Moro et al. (2019) aimed to increase the reliability of results and their appropriateness in complex, multidisciplinary fields of study.

In view of the above, this study proposes a hybrid methodology to carry out a systematic review of the literature on a specific topic, using a text mining process with a basic dictionary, divided into the following stages.

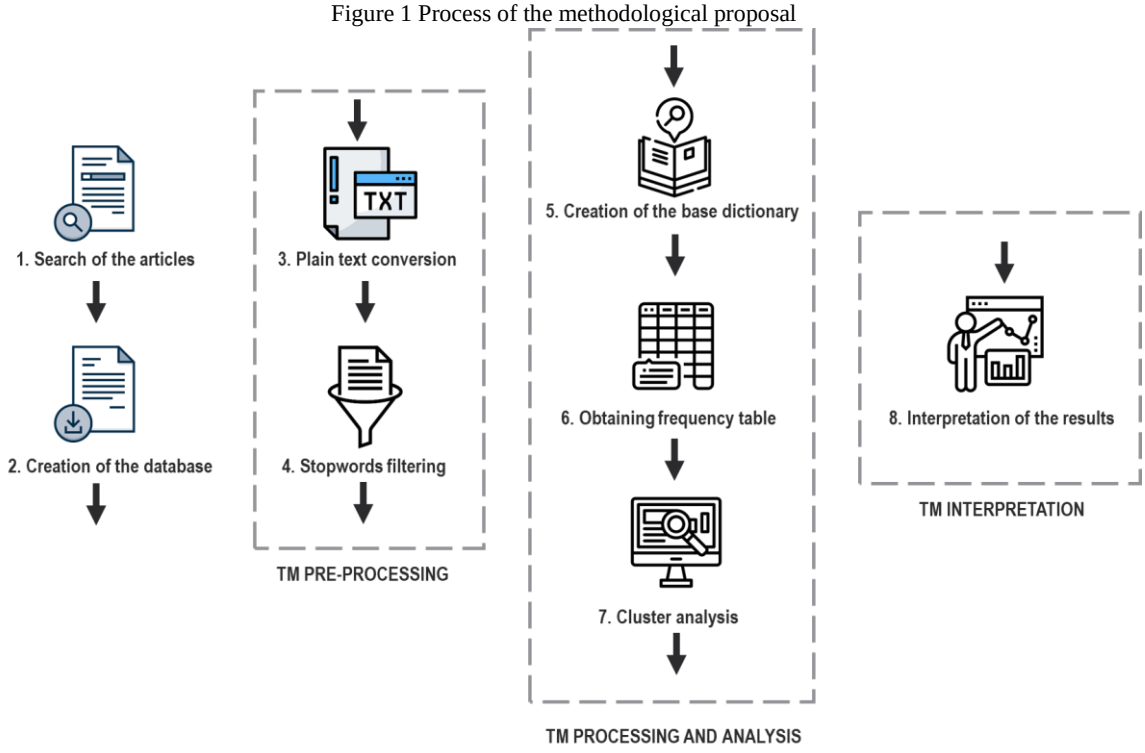
1. *Search of the articles to be analysed by means of bibliography reference databases such as Web of Science and Scopus.*
2. *Creation of the article database.* Firstly, all the articles to be included in the study should be downloaded, thus creating the article database (complete database). Next, a related data base also needs to be created, including only the abstracts and keywords of each individual paper (reduced database). The complete database contains such abstracts as well as keywords.
3. *Plain text conversion of the databases.* At this stage, both the complete papers and the documents with the abstracts and keywords must be converted to plain text (.txt format) so that they can be read during the process. This step is based on the search for the robustness of the topics included in the dictionary. Furthermore, comparing the results of both databases lets us corroborate the practices of many studies where only the abstracts and keywords of the papers to be analysed are used to review the literature with text mining processes.
4. *Stop-words filtering and elimination.* This stage involves filtering and eliminating in both plain text databases (1) stop-words (i.e. words without a meaning in and of themselves, e.g. prepositions, adverbs, etc.), (2) punctuation signs and/or numbers, and (3) non-discriminatory words that commonly appear in scientific research (e.g. 'author,' 'hypothesis', 'study,' 'analysis,' 'research,' among others).
5. *Creation of the base dictionary.* This stage involves the semi-automated creation of two dictionaries by means of a content analysis: a dictionary with the complete database, and another one with the reduced database. Objectiveness is strengthened by using a semi-automated process and using the two dictionaries ensures more precise, robust results. The creation step includes the following sub-stages:
    a. *Content analysis.* This sub-stage is carried out automatically and involves obtaining a list of categories established by a group of keywords. It is therefore a list of the categories which appear more often within the papers and of the keywords within each category (most frequent keywords). This process is repeated with each database, i.e. both the complete and reduced databases.
    b. *Reorganizing categories and keywords.* This sub-stage is done manually and involves reducing the categories derived from the previous sub-stage, if necessary. To that end, the system firstly draws the categories that most frequently appear in the texts and puts them in order, from the most frequent to the least frequent. Secondly, some of the keywords in lower categories are reassigned to higher categories to enhance comprehensiveness and make sure that all keywords related to a given category are grouped under it. This step, which requires a certain level of mastery over the research topic, is also carried out with both databases (complete and reduced).
    c. *Choosing the most specific dictionary on the research topic.* This sub-stage involves choosing the dictionary that best represents the research topic. It is also done manually, by comparing the

categories obtained from each dictionary, as well as the keywords that make them up. The aim is to create the dictionary using the categories that cover the research topic in its entirety, with the least number of keywords in each category if possible. By following this criterion, precision is enhanced, and we can create a concrete dictionary comprised of the most specific terms within each category.

6. *Obtaining frequency tables.* Once the base dictionary has been chosen to continue the process, a N x p-type cross frequency table is created, where 'N' represents the different items, and 'p' the keywords belonging to each category in the dictionary. This table provides the frequency of occurrence of each word belonging to the dictionary in each paper.
7. *K-means cluster analysis.* At this stage, the previously obtained frequency table is subjected to a k-means cluster analysis to identify the optimal number of groups of academic papers. This will represent the current lines of research on the topic. This process results in the cluster to which each analysed paper belongs.
8. *Interpretation of the clusters.* In this last stage, the researcher must describe the resulting clusters that correspond to the lines of research that have been studied for the research topic. It is also possible to extract other useful information about each cluster: most representative authors, chronology of publications, most appropriate magazines, etc. In addition, the research can promote discussion and include future lines of research based on the results.

As can be seen in Figure 1, which shows a graphic with the different stages of this methodological proposal, the first two stages come before the text mining process, mainly featuring the initial search and preparation of the academic papers to be analysed. In addition, stages 3 and 4 correspond to the text mining pre-processing step. Stages 5, 6 and 7 correspond to the text processing and analysis step. More specifically, stage 5 involves the text processing step, and stages 6 and 7 the text analysis. Lastly, stage 8 consists of the third and final text mining step, i.e. viewing and interpreting the results.

Figure 1 Process of the methodological proposal



Source: Own elaboration with icons obtained from flaticon.com

Review of the literature on neuromarketing

In this section, a systematic review of the literature on neuromarketing will be carried out, using the method proposed in the previous section.

Stages 1 and 2: Initial search and preparation of the papers

To cover the largest possible number of papers on neuromarketing, and taking into account the multidisciplinary nature of the research topic, the two most important scientific databases on this field were used, where the quality assurance process was applied: Web of Science y Scopus. More specifically, the entire Web of Science collection and the first two quartiles of Scopus were used.

Given the large scope of neuromarketing, its multiple applications and the need to structure the research on this field, a search on terminology that was as broad as possible was carried out. That is the reason why the selection criterion used was that articles should include some of the following terms in the title, abstract or keywords: 'Neuromarketing', 'Neuroscience and Marketing' and 'Neuroscience and Advertisement'. As a result, the study data base is made of 296 papers dated from January 2010 to January 2019.

Firstly, an Excel database was created including the following fields: abstracts, keywords, authors, date of publication and journals. The database allowed us to carry out a first analysis of the papers selected. It was also used to generate the reduced database for one of the base dictionaries.

Secondly, the 296 papers were downloaded in PDF format. These made up the entire selection of papers which were later used to create the other base dictionary.

Once both databases were established and before starting the content analysis, an analysis was carried out on the distribution of papers during the years of study. As shown in Figure 2, the distribution shows a growing trend in the number of papers published on neuromarketing with an upturn in 2015. On the other hand, the broad scope and applications of neuromarketing are also evidenced in the large number of magazines where the 296 papers chosen were published, as well as in the wide range of categories to which the papers belong, such as psychology, business, neuroscience, economics, social sciences, communications and multidisciplinary. The total number of magazines is 178, of which only 47 published more than one paper. The ten magazines with the highest number of papers on neuromarketing are: IEEE Xplore (17), European Journal of Marketing (8), Frontiers in Neuroscience (8), Journal of Advertising Research (7), Journal of Marketing Research (7), Journal of Neuroscience Psychology and Economics (7), Cogent Psychology (6), Procedia Social and Behavioral Sciences (6), Frontiers in Human Neuroscience (5) and Journal of Economic Psychology (5). Furthermore, its large scope is also evidenced in the high number of authors that published the 296 papers, i.e. 776 researchers, as well as in the low authorship frequency. In this sense, we should highlight Fabio Babiloni as the author of 14 papers, Giovanni Vecchiato with 11 papers, and Patrizia Cherubino with 8. As for the distribution of papers published by the rest of authors, 4 authors appear in 5 papers, 9 authors appear in 4 papers, 30 authors appear in 3 papers, 142 authors appear in 2 papers, and 588 authors appear in only one paper (see Figure 3).

Figure 2 Distribution of articles per year

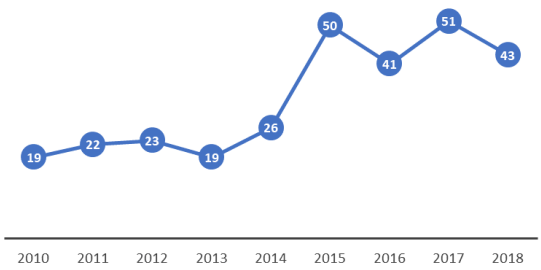
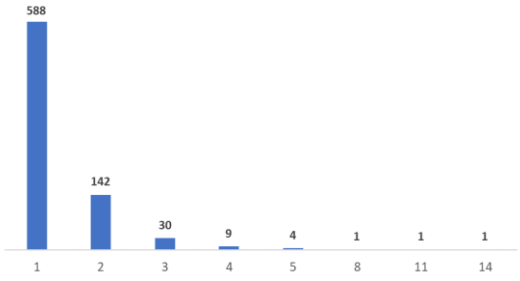


Figure 3 Distribution of authors by number of publications



Stages 3, 4 and 5: Creation of the base dictionary

These three stages were aimed at creating the base dictionary that would be used in the next phase. Stages 3 and 4 involved the text mining pre-processing step, and stage 5 consisted of the processing step. The two dictionaries were created following a semi-automated process by means of a content analysis. To that end, Qda-Miner, a tool for qualitative analysis, and WordStat, a programme for content analysis and text mining, were used.

Creation of the first dictionary:

The process started by creating the first base dictionary using the reduced database containing the abstracts and keywords of the 296 papers, which were converted to plain text format (.txt). The next step was filtering and eliminating stop-words. For this, Qda-Miner has a list of predetermined stop-words in the language of the studied texts (English in this case), including accessory words such as prepositions, articles and adverbs. After the first filter, we had to manually add to this general list of stop-words several common scientific language terms that were not relevant to the research topic, such as 'author,' 'hypothesis,' 'study' o 'research,' following the recommendations made by Guerreiro et al. (2016).

After filtering the stop-words, the content analysis was done using WordStat, based on extracting categories made of keywords. With three parameters (segmentation type, maximum number of categories and loading), the optimal number of categories and keywords were extracted, taking their frequency into account. Segmentation is the co-occurrence of terms in the same text, paragraph or sentence. Following the recommendations made by the software creators for large texts with a high number of words, such as scientific papers, the segmentation type chosen was paragraphs. This means the algorithm chose the terms with the highest frequency of occurrence in each paragraph for the text (papers) studied to create the different categories. As for the second parameter, the software allowed us to set the desired number of categories with 60 being the maximum allowed and the number that we chose for the present study. With regard to the third parameter, the programme allowed us to set a minimum loading value for a term to be part of the solution. This way, only the most representative terms for the given category appear. The software creators recommended setting values between 0.2 and 0.3. For this study, 0.3 was chosen to ensure the highest suitability of the terms to be included in the dictionary, given their highest level of occurrence in the papers analysed.

Once the dictionary with 60 categories was obtained, it was then reduced to achieve a set of categories that were more homogeneous within themselves, but more heterogeneous among themselves. This required us to view the process as semi-automated. Firstly, the 20 categories with the highest frequency of occurrence in the papers were chosen. Secondly, the contents of the remaining categories were totally or partly incorporated into the first set of 20 categories according to their great similarity, in order to achieve a reduced group of categories which was, at the same time, integrative and wholistic. As a result, a first (reduced-based) dictionary was produced, comprised of 20 categories and 230 keywords within these categories in total (see Table 1).

Table 1 Reduced-based dictionary (abstracts and keywords)

No.	CATEGORY	KEY WORDS WITHIN THE CATEGORY
1	Brain Functions	Functional, activation, brain, frontal asymmetry, frequency, Hz, frontal, feature, identify, hemisphere, signals
2	Ethical Aspects	Ethical, issues, ethics, association, humans, interdisciplinary, legal
3	Health Applications	DSM, diagnostic, disorders, involvement, advances, drug, biomedical, innovation, health, healthy, jaspers, language
4	Business Applications	Economic, behavioural, disciplines, fields, benefit, issue, financial, management, behaviour, attractiveness
5	Marketing Applications	Experience, effects, interactive, human, functions, aesthetic, images, intention, involvement, benefit, feelings, imagery, habits, interest, logos, branding
6	Advertising	Ad, exposure, effectiveness, automatic, advertising, interactive, elderly, adults, affect, brand, impact, bias, attentional, experimental, advertisement, attributes, branding, behavioural, elements, attractiveness, campaigns, effective, equipment
7	Product Categories	Car, environment, buying, explores, interdisciplinary, called, investigated, food
8	Neuroscience	Electrical, devices, industry, advantages, insights, functions, interactive, familiar, biological
9	Neuromarketing	Emotion, emotional, arousal, assess, gender, females, differences, experiment, awareness, advertisements, attitude, association, intention, effect, intelligence, emerging, advanced, knowledge, female, male

10	Neuromarketing Techniques	Empirical, behaviour, enhance, education, educational, experts, effective, assessed, experienced, explored, directly, engagement, interactions, detection, ability, art, pattern, emotions, measurements, measured
11	Electroencephalogram (EEG)	Electroencephalographic, heart, interest, band, asymmetry, arousal, EEG, adopted, interface, enables, interaction, interactive, brain sensors, concentration, relaxation, alpha, gamma, beta, analysed
12	Facial Expressions	Expression, facial, image, face, art, experiments, fast, accuracy, insight, individual, attention, action, benefits, digital, fear, facial recognition
13	Heart Rate	Heart, experience, attention, action, benefits, digital, cardiogram
14	Functional Magnetic Resonance Imaging (fMRI)	Functional, imaging, fMRI, activity, magnetic, cerebral
15	Eye Technics	Gaze, eye, focused, audience, attention, eye-tracking, immersive, experiences, eye-blinking
16	Functional Near-Infrared Spectroscopy (fNIRS)	fNIRS, exposed, innovative, effectiveness, experiments, appears, applying, limitations
17	Electromyography (EMG)	EMG, electromyography, sensorial, helmet
18	Electrodermal Activity (EDA)	Effort, electrodermal, audio-visual, exploratory, experts, sensors, conductivity, wired, wireless
19	Event-Related Potential (ERP)	Event, ERP, automatic, amplitude, larger, contrast
20	Investigation Techniques	Focus, groups, industry, interviews, individuals, advantages, form

After an exhaustive analysis of these 20 categories in Table 1, it can be stated that the research lines and topics in the field of neuromarketing are quite diverse given their multidisciplinary nature. The first category mainly comprises all the terms related to the morphology and functions of the brain in and of themselves. The second category includes the ethical aspects underlying the application of new technologies for the study of human behaviour. Everything related to studying the mind and its workings can lead to an inappropriate use of the information obtained, as well as to fostering fear in the customer, who may think that these techniques can be used to manipulate their conduct. That is why ethics is a very recurrent topic in this field.

The three following categories (no. 3, 4 and 5) deal with three of the most common applications of neuroscience, i.e. health, business and marketing applications. In each category, we can find the most frequently used terms in studies on neuroscience, which vary among each other significantly based on their applications. The following category comprises words related to advertising (category 6). This is the most common application of neuromarketing or consumer neuroscience due to the great contributions made by using this new discipline in the field of marketing. In addition, given how important it is for companies to explore the potential of neuromarketing to solve business problems, it was deemed relevant to keep the category comprising the different types of products to which this new technology has been applied most frequently (category 7).

Categories 8 and 9 are the most generic ones in the dictionary. They collect the most extended, usual terms referring to both neuroscience and neuromarketing/consumer neuroscience. These categories encompass a range of representative terms found in scientific papers on these academic fields, including examples such as ‘emotion’ and ‘experiments’.

The remaining categories (10 and 19), except for the latter, refer to the different neuromarketing techniques. From a general point of view, it is category 10 that comprises the different existing techniques and tools, as well as the terms that are common to all of them. Each category is specifically related to a tool: (11) electroencephalogram (EEG), (12) facial expressions, (13) heart rate, (14) Functional Magnetic Resonance Imaging (fMRI), (15) eye technics, (16) Functional Near-Infrared Spectroscopy (fNIRS), (17) electromyography (EMG), (18) Electrodermal Activity (EDA) and (19) Event-Related Potential (ERP).

Finally, the last category, labelled ‘Investigation Techniques’, includes terms related to the traditional investigation techniques used in the field.

Creating the second dictionary:

Following the methodological proposal, the above-described process was repeated with the full base, i.e. with the full corpus of 296 papers converted to plain text (.txt). This stage was aimed at enhancing the rigour of the process and ensuring valid, robust results because the definition of the base dictionary was derived from the comparison between the two created dictionaries.

The results of the analysis, compiled in Table 2, produced a base dictionary with 13 categories, which were gathered in the first dictionary, and 96 terms, also included in the first dictionary. The second dictionary does not comprise the three categories that were present in the first: (1) ‘Neuroscience’, where the key words were more closely related to the medical field than with the application of neuroscience to marketing; (2) ‘Neuromarketing Techniques’, a very generical cut-off category that involved certain aspects of the different neuromarketing techniques and included keywords that were present for the most part in other categories of the second dictionary; and (3) ‘Investigation Techniques’, a category that included every term related to traditional market research techniques, which are also used in combination with neuromarketing tools in many studies, but are not exclusive to the research topic. Four other categories (‘Heart Rate,’ ‘Electromyography (EMG),’ ‘Electrodermal Activity (EDA)’ and ‘Event-Related Potential (ERP)’) were not included either. These referred to neuromarketing tools or techniques that are common or frequently used in combination with other techniques that were more typical for the research subject matter. Despite eliminating the above seven categories from the dictionary, a careful analysis of the contents in the second dictionary allowed us to confirm that it is more detailed and specific. In this sense, it focuses on the aspects most closely related to neuromarketing, as well as the most frequent techniques, without omitting ethical aspects.

On the other hand, not all the words included in the seven eliminated categories disappeared from the study, because some of them were incorporated into other categories of the second dictionary. More specifically, out of the 63 words comprised by the eliminated categories, 6 were included in other categories, such as ‘behaviour’, which went from ‘Neuromarketing Techniques’ to ‘Neuromarketing’, and ‘amplitude’, which went from ‘Event-Related Potential (ERP)’ to ‘Brain Functions’.

These results allowed us to support the validity and robustness of the dictionary and to provide empirical evidence of the suitability of using complete corpora of papers to be analysed, not only their abstracts and keywords. This led us to create a more detailed, specific dictionary. It should be highlighted, however, that both alternatives resulted in similar dictionaries that were both suitable for text mining afterwards. This study, in fact, relies on the second dictionary as a base dictionary. Using a dictionary as an element of pre-processing is aimed at achieving a more precise, reliable text mining process; therefore, the more specific the dictionary is, the more precise the subsequent study will be.

Table 2 Full-based dictionary

Nº	CATEGORY	KEY WORDS WITHIN THE CATEGORY
1	Brain Functions	Brain, neural, network, recognition, SNN, model, arousal, valence, emotional, amplitude, stress, left, hemisphere, beta, alpha, theta, gamma, band, waves, Hz
2	Ethic Aspects	Ethical, ethics, practices, companies, code
3	Health Applications	Disorders, mental, psychiatric, DSM, clinical, trials, psychiatry, health, public, patients, dopamine, stress, psychologic
4	Business Applications	Industrial, management, business, economic, political, cultural, neuroeconomics
5	Marketing Applications	Marketing, consumer, social, purchase, customer, service, aesthetic
6	Advertising	Ad, exposure, brand, product, advertising, effectiveness, television, media, preference, commercials, TV, recall, celebrities, spokesperson
7	Product Categories	Product, harm, WOM, destination, image, pictures

8	Neuromarketing	Consumer, neuroscience, behaviour, emotions, positive, negative
9	Electroencephalogram (EEG)	EEG, signal, electrodes, electrode
10	Facial Expressions	Facial, expression, recognition
11	Functional Magnetic Resonance Imaging (fMRI)	Imaging, fMRI, individuals
12	Eye Techniques	Eye-tracking, eye, tracking, visual, attention, stimuli
13	Functional Near-Infrared Spectroscopy (fNIRS)	fNIRS, experiments

The first category in the second questionnaire includes all the terms related to the brain, both its morphology and brainwaves as measures of its activity during the course of the experiments. The second category comprises the ethical aspects of this new discipline.

Categories 3, 4 and 5 show the most common applications of neuroscience (health, business and marketing), whereas category 6 gathers the most frequently used terms on the application of neuromarketing or consumer neuroscience in the field of advertising. Category 7 includes the categories of products to which this new discipline has been applied.

Category 8 collects the most generic, usual terminology of neuromarketing or consumer neuroscience used in scientific papers on this field, such as 'emotion' and 'behaviour'. The remaining categories (9 to 13) are related to the techniques that are most frequently used in neuromarketing: electroencephalogram (EEG), facial expressions, Functional Magnetic Resonance Imaging (fMRI), eye technics and Functional Near-Infrared Spectroscopy (fNIRS).

Stages 6 and 7: Clustering of papers

Using the WordStat software and based on the second dictionary, a cross table in CSV format was created, showing how often a keyword appears in each of the 296 papers (absolute frequencies), oscillating between 1 and 571. This wide range, determined by the size of the different papers, can influence the results of the cluster analysis. For this reason, a new cross table (N x p type, with N being the papers, and p the keywords) was created, where absolute frequencies were replaced by standardized values representing the importance of each keyword in each paper. To generate this table, we calculated (1) the total number of occurrences of each word in the 296 papers, ranging between 234 and 9312; (2) the average of occurrences of the keywords (Mean=1507.35, D.S.=1633.38) to select only those with an occurrence rate that was higher than 80% of the average (1205.88), which allowed us to reduce the number of keywords to be analysed to 41; and (3) the relative frequencies of each of these 41 terms in each paper, taking the sum of their occurrences or absolute frequencies in each paper as a reference. Thus, values between 0 and 1 were obtained, showing the weight of the terms in each paper.

Taking this table as a database, the different papers were sorted into groups using a k-means cluster analysis with the IBM SPSS statistical software package, version 25. K-means clustering has been widely used in several fields (Tarczynski 2011) and has recently been applied to text mining studies (Wang et al. 2018). This is due to its easy implementation, simplicity and capacity to manage large data sets with enhanced scalability while producing excellent results (Tarczynski 2011; Wang et al. 2018). The results of this analysis reveal the existence of four clusters, while also revealing the relationship of each of them to the 296 papers analysed. The total number of researchers who have been listed as authors of these articles is 826. The frequency of authorship ranges from 1 to 13, with 87.16% of the authors having signed only one article, 12.60% having signed between two and seven and only 0.24% having signed more than 10 articles. The researchers with the highest productivity in neuromarketing are listed in Table 3. These results show that this is an area that is still very little researched, insofar as there are very few leading authors in the field. Perhaps this fact is due to the multidisciplinary nature of the topic, which leads to a wide dispersion of authorship, which ratifies the starting premises of this work. The two most relevant authors were Babiloni (13 articles) and Vecchiato (11 articles), who are also among the top three in clusters 2 and 4.

Table 3 Top ten authors of neuromarketing

AUTHOR	NUMBER OF ARTICLES
Babiloni, Fabio	13
Vecchiato, Giovanni	11
Cherubino, Patrizia	7
Maglione, Anton Giulio	7
Lee, Nick	6
Astolfi, Laura	5
Cincotti, Febo	5
Fallani, Fabrizio De Vico	5
Ma, Quingguo	5
Mattia, Donatella	5

The first cluster is made of 44 papers (14.86%), including studies focused on defining general concepts, mainly about neuromarketing and neuroscience, or the new 'neuro' disciplines. The second cluster consists of 78 papers (26.35%), with a large part of them being empirical, and all of them related to defining and applying the different neuromarketing techniques and tools. The third cluster is much more specific, with only 11 papers (3.72%), related to the application of neuroscience or neuromarketing to the service sector. Finally, the fourth cluster, including the largest number of papers (163, 55.07%), is not focused on neuromarketing or neuroscience. These are mentioned, however, when referring to future research lines or their inclusion as a new technology that should be applied to other disciplines such as experiential marketing.

Stage 8: Viewing and interpreting the clusters

In this stage, the researcher must view and interpret each resulting cluster. To that end, the most representative papers on the topic of each cluster are used, while also referring to the papers with notable peculiarities, e.g. new lines of research. That is why the following paragraphs will explain the current lines of research on neuromarketing, which is the topic of focus of the intended literature review.

Cluster 1. Theoretical research: Definition of concepts

This cluster collects 44 theoretical papers, mostly offering definitions of important concepts on neuromarketing. These definitions range from generic notions, such as neuromarketing and the new 'neuro' sciences in the business and economic fields, to more specific concepts, such as the ethics of neuromarketing. The total number of authors in this cluster is 100, with 85% signing only one article, 11% two and the remaining 4% between three and five articles. The most relevant authors in this cluster are Lee (5 articles), Chamberlain (4 articles) and Huettel (3 articles).

The progress of neuroscience and a deeper understanding of the human brain have led to the creation of new lines of research in social sciences, mainly on marketing, business and economy (Gillingwater and Gillingwater 2011). This has given way to new concepts such as neuromarketing, organizational cognitive neuroscience, neurostrategy and neuroeconomics.

Neuromarketing is generally defined as the use of neuroscientific techniques, specialised in cognitive research and applied to marketing (Cruz et al. 2016; Lee et al. 2017, 2018). The literature suggests an essential difference between neuroscience as a scientific process, and neuromarketing as a practical application of neuroscience, which involves measuring the brain's activity by means of its different techniques, such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), etc. (Cruz et al. 2016; Lee et al. 2017).

There are other authors who view neuromarketing as a contribution derived from integrating neuroscientific techniques and theories in the research of consumer behaviour (Kenning and Linzmajer 2011). This helps academics better understand the decision-making and the processes related to it (Plassmann et al. 2015). By measuring the brain's processing, neuromarketing also provides a deeper understanding of consumer response to marketing stimuli. This can subsequently help to improve the design, implementation and efficiency of marketing strategies (Bakardjieva and Kimmel 2017).

The existence of several different definitions of neuromarketing in the literature led Lim (2018, p.2) to suggest a unified definition of neuromarketing in the following terms: 'an interdisciplinary branch of knowledge that is predicated on the use of neuroscientific concepts, theories, and methods (or tools and techniques to record brain and neural activity during behavior) to study the brain and nervous system in the pursuit of understanding instinctive (or natural) human behavior, in terms of cognitions and emotions, conscious and unconscious, in response to a marketing stimulus (e.g., markets, marketing exchanges), whereby the knowledge resulting from a neuromarketing investigation contributes to the development and advancement of marketing theory and the planning and implementation of marketing strategies, with (e.g., to make a sale) and without (e.g., to influence behavior for a social good) commercial marketing goals.'

The enormous potential of neuromarketing has instilled great enthusiasm to large companies providing marketing services. Specialised departments have been founded in these companies, and other firms exclusively focused on neuromarketing research have also been established (Plassmann et al. 2015). This interest on neuromarketing is mainly due to the possibility of collecting information using neuroscientific techniques which could not be collected before with traditional techniques such as surveys (Hsu 2017; Lim 2018). The possibilities opened by neuromarketing, however, again gave raise to concerns related to intrusiveness and physiological measurements, as well as the potential applications of the results obtained from neuromarketing research (Bakardjieva and Kimmel 2017). In this context, the currently most usual method is brain-scanning, which is more intrusive than physiological measurements and therefore result in more ethical concerns. The study of unconscious brain activity has been met with wide-spread rejection because the results of research could be used by companies to influence consumer behaviour through commercial messages. The consumers' privacy could even be violated if those results are given to third parties for business purposes (Bakardjieva and Kimmel 2017). Despite the criticism, the defenders of neuromarketing have suggested that, first and foremost, malpractice should not limit the progress of scientific knowledge. And secondly, the application of neuromarketing and the use of brain-scanning techniques are regulated by and subject to a number of ethical principles (Bakardjieva and Kimmel 2017). These conflicting views have led researchers to create the Ethical Guideline in Neuromarketing (EGNM), contained in the Ethical Code of Conduct of the Neuromarketing Science and Business Association (NMSBA), including a number of guidelines for ethical studies on *neuromarketing* (Hensel et al. 2017; Bakardjieva and Kimmel 2017).

The inclusion of neuroscience in the business field gave way to new concepts such as organizational cognitive neuroscience and neurostrategy. The former, which represents the union of neuroscience and the studies on management and organization, adopts a twofold approach: on the one hand, the application of neuroscientific theories and their methodologies to the study of organizational research, and on the other hand, the use of the findings and results of neuroscience as a basis for new hypotheses in organizational studies as a reverse research work (Butler et al. 2016). The latter concept, which integrates neuroscience with strategic management, provides new opportunities for researchers to validate constructs, prove theories, measure variables and establish new hypotheses to improve strategic management (Powell 2011).

Finally, the result of integrating neuroscience and economy gave rise to the concept of neuroeconomics, thus making great progress on decision-making, individual behaviour and social interaction (Pykett 2013). This concept is closely related to the implementation of neuroscientific techniques to the understanding of economic decision-making (Pykett 2013).

Cluster 2. Neuromarketing techniques

This cluster is made of 78 papers, most of them empirical, related to the different techniques used in neuromarketing. Neuromarketing uses neuroscientific tools to empirically measure unconscious preferences and cognitive processes such as decision-making, as well as to assess value preferences and marketing stimuli, e.g. advertising campaigns, brand images and pricing strategies (Harris et al. 2018a). In this cluster, the total number of authors is 318, with 90.57% having signed one article, 5.35% two, 3.45% between three and five, and 0.63% seven or eight articles. The number of papers signed by the same author in this cluster is higher, probably due to the versatility of neuromarketing techniques. The most relevant authors in this cluster are Babiloni (8 articles), Vecchiato (7 articles) and Cherubino (5 articles).

The most usual technique is electroencephalography (EEG) due to its high temporal resolution, non-invasiveness, simple management, wireless connectivity and low operation and maintenance costs in

comparison with other neuroimaging techniques (Yadava et al. 2017). Its use encompasses multiple topics, with the most usual being the study of consumer behaviour in general and consumer reaction to marketing stimuli, in particular. As an example, in the study made by (Ohme et al. 2010), EEG was used to identify the brain cortex's frontal activation to three creative proposals of an advertisement for a TV brand. The authors found that EEG is a most suitable technique in advertising pre-tests to see if the advertisements meet the goals set by the brand. This cluster includes other studies where EEG was applied to the advertising industry to (1) test the advertising effectiveness (Wei et al. 2018), (2) understand future consumer behaviour when viewing an advertising spot (Vecchiato et al. 2011, 2012; Cartocci et al. 2016; Bettiga et al. 2017) or (3) measure the advertising appeal of a spot (Wang et al. 2016; Touchette and Lee 2017). On the other hand, there is a number of papers that use EEG to study consumer preferences from different approaches: (1) aesthetic preferences through visual stimuli (Boksem and Smidts 2015; Chew et al. 2016; Teo et al. 2018), (2) preferences in the face of decisions between two choices (Vecchiato and Babiloni 2011; Khushaba et al. 2013), and (3) purchase preferences in different scenarios (Lee et al. 2014; Yilmaz et al. 2014; Yadava et al. 2017).

The high temporal resolution of EEG provides data almost in real time, which enables researchers to more easily identify the cause-effect relationships between stimuli and cognitive responses. These responses manifest in the shape of one or more Event-Related Potentials (ERP) or EEG neuronal waves. ERP is a specific application of the EEG method, where at the beginning of the stimulus a time zero point, thus only registering ERPs related to the stimulus studied (Lin, Cross and Childers 2018). This cluster gathers some papers highlighting the precision of this technique and its usefulness in carrying out quite specific experiments on very different topics. In this sense, we should highlight the studies made by Lin, Cross and Laczniak (2018) and Lin, Cross, and Childers (2018), focusing on the relationship between smells and emotions. In the former study, it is proven that olfactory images can modify the evaluation of advertisements, because the olfactory sensation, without a real smell, influences consumer attitudes and cognition. The authors also proved the influence of individuals' olfactory sensitivity on results, given that olfactory images create a positive cognitive response in individuals with low olfactory sensitivity, and a negative response in those with high olfactory sensitivity. In the latter study, the authors provide support for the existence of automatic negative emotions in individuals with high olfactory sensitivity. The significance of EEG as a technique can also be observed in its use combined with other techniques such as eye-tracking (Christoforou et al. 2017), functional near-infrared spectroscopy (fNIRS) (Laghari et al. 2014), as well as other neurophysiological measures (Laghari et al. 2014), and even computer tools such as machine learning (Lin et al. 2014).

The second technique most frequently used in neuromarketing is Functional Magnetic Resonance Imaging (fMRI). It is a non-invasive neuroscientific technique that uses radio waves and magnetic fields to measure neuronal activity (function), while magnetic resonance measures the brain's structure (Harris et al. 2018a). This technique registers the signs and variations of brain oxygenation in the different areas of the brain. This is why it is very appropriate to identify specific areas of brain activation with a very high resolution. Its main disadvantages are its deficient temporal resolution (Harris et al. 2018a) and high cost (Telpaz et al. 2015).

Just like EEG, fMRI has been applied to different fields within neuromarketing, with the most relevant being the study of consumer behaviour. Among the main studies on fMRI applications, we should highlight (Couwenberg et al. 2017). The authors analysed the influence of individual behaviour before marketing stimuli. The results of the study prove that functional and experiential elements involve different areas of the brain associated to lower and upper-level cognitive processes, and that the activation of such areas is closely related to greater marketing effectiveness. fMRI has also been used to study aesthetics of brand packaging and its importance in the purchase of a product (Reimann et al. 2010). Finally, fMRI has been used in combination with machine learning to predict purchase decisions (Wang et al. 2015) or to understand an individual's brain processing in the face of brands with personality (Chen et al. 2015).

In addition to these widely spread techniques, there is another set of more specific, highly relevant techniques such as (1) eye-tracking, which is used to measure movements and changes in pupil dilation and contraction (Harris et al. 2018a); (2) electrodermal activity (EDA), which is used to measure changes in skin perspiration and captures an emotional episode (Lajante et al. 2012); and (3) facial expression, which involves decodifying facial expressions automatically through software (Stasi et al. 2018). On the other

hand, there is a different group of techniques that is used less frequently: (1) mind Wave (Yang 2018), (2) eye-gaze metric (Christoforou et al. 2015), (3) biometric techniques (Steele et al. 2013), (4) medial frontal activity (Lin et al. 2010) and (5) facial electromyography (fEMG) (Rasch et al. 2015), among others.

Lastly, there is a group of highly relevant theoretical papers for the literature review on neuromarketing, more specifically, to choose the most appropriate neuroscientific technique for the application to be implemented. Among them, the study made by (Harris et al. 2018a) stands out. The authors carried out an exhaustive theoretical review on the most usual techniques within the field of neuromarketing in the last few years, explicitly including its particularities, applications, strengths and limitations.

Cluster 3. Customer Service

This is the most specific cluster, encompassing 11 papers related to neuroscience or neuromarketing, applied to service marketing, in general, and healthcare services, in particular. The number of authors in this cluster is 40, with no author signing more than one article.

The combination of neuroscience with service marketing results from applying neurophysiological measures to the collection of business data. The work made by (Neghina et al. 2013) revealed the benefits of service marketing based on consumer data and their metrics, collected both from traditional sources of information (surveys, experiments, focus groups, observations, etc.) and more innovative sources (neurophysiological data, such as for example, eye-tracking, EEG, fMRI, MEG, etc., and digital data). The authors associated these data and metrics to business strategies and integrated them into the control panel. Thus, they managed to more precisely measure the return on investment (ROI) of marketing strategies and more accurately predict future expenses in this area. In addition, the authors firmly emphasized the capacity of data to define and evaluate tactical and strategic marketing decisions (Neghina et al. 2013).

The usefulness of neuromarketing within service marketing is highlighted in (1) the use of consumer metrics to help companies assess performance and predict financial results (Arens and Rust 2012; Neghina et al. 2013), (2) the study of brand expansion strategies (Yang et al. 2018), and (3) the study of consumer-perceived value in online after-sale services (Wang et al. 2017).

Within this cluster, there is a sub-group of papers focused on neuromarketing applied to healthcare services, such as the studies made by (Berthoud 2012), and (Nutt and Attridge 2014). They recommend using neuromarketing to promote the ingestion of healthy products among the population, especially among children and teenagers. The use of neuromarketing has been effective in non-healthy food companies to define the emotional and cognitive stimuli influencing specific areas of the brain that encourage people to eat this kind of food. Finally, special emphasis should be placed on the work made by (Shi et al. 2017). By means of neuroimaging techniques (fMRI), the authors analysed the advertising efficacy of anti-tobacco advertisements.

Cluster 4. Neuromarketing as a secondary or marginal approach

The last cluster is the most extensive, collecting 163 papers of varying nature, where neuromarketing plays a secondary or very marginal role in the theoretical foundation or any other section. The total number of authors is 439, of which 90.89% are signatories of only one article, 7.06% of two and 2.05% between three and five articles. The most relevant authors are Babiloni (5 articles), Ma (4 articles) and Vecchiato (4 articles).

Most papers related to neuromarketing cover many topics, ranging from literature reviews on specific applications, experiments with neuroscientific techniques or new applications of neuromarketing, to new neuroscientific tools. Thus, some papers included in this cluster start with a theoretical review of neuromarketing before using a specific technique or application belonging to this field. That is the case with the group of papers combining neuromarketing techniques or applications with theoretical frameworks on neuromarketing or neuroscience. This approach is not as defined as in other contexts, which is why the above-mentioned papers have been included in this cluster. On the other hand, there is another set of papers focused on marketing in general which, however, mention or include a specific section on neuroscience or neuromarketing in their lines of work or future lines of research. Lastly, the remaining papers are related to generic topics, but also mention neuromarketing or neuroscience in the body of the text or conclusions.

Among the papers in the first group, the work of (Agarwal and Dutta 2015) stands out. Besides defining concepts such as consumer neuroscience and neuromarketing, the authors placed special emphasis in differentiating both concepts, which are used indistinctly in the literature despite the little nuances that set them apart. They defined consumer neuroscience as the academic research resulting from the combination of neuroscience, psychology and marketing, whereas they associate neuromarketing to the practical application of neurophysiological tools. (Agarwal and Dutta 2015) foresaw a great future for these disciplines in research on marketing and consumer behaviour. In fact, they stated that consumer neuroscience will be responsible for creating new theories, but will also be essential in refuting the traditional marketing theories, while neuromarketing will be very advantageous in improving the effectiveness of marketing strategies.

In the sub-group of papers related to marketing in general and its applications, the study made by (Petit et al. 2015) deserves special attention. The authors highlighted the importance of neuromarketing in the new current of experiential marketing, where the main aim is to create multi-sensorial experiences that enhance consumer sensitivity. For the authors, the neuroimaging techniques can help researchers detect the response by individuals to specific sensorial stimuli in certain areas of the brain.

The papers included in the last sub-group do not follow any common pattern, except for mentioning neuromarketing in some of their sections, usually in the conclusions or future lines of research. We should highlight the review made by (Labrecque et al. 2013) on the impact of colour in consumer behaviour. This review suggests the basis for research on colour in the field of marketing. To that end, it contextualizes several studies on the topic carried out in other disciplines such as neuroscience, psychophysics, visual cognition, and biology, where neuroimaging techniques (e.g. eye-tracking) are used to research colour perception from areas of the brain.

Discussion on future lines of research

Despite the multidisciplinary nature of neuromarketing, which has resulted in very a heterogenous scientific production, this work has defined its main lines of research based on a systematic literature review from a wholistic approach, dealing with all the aspects of the discipline, still in development. In addition to this first academic contribution, we can derive a number of future research lines based on our study. Some of them have already been suggested by the researchers in their respective studies, whereas others are derived from the gaps identified in the literature. The future lines of research will be presented in the following paragraphs more specifically.

The need for a standardized definition of neuromarketing

As was already mentioned in the first cluster, there is a large variety of definitions of neuromarketing. The lack of a standardized definition recently led (Lim 2018) to propose a new definition based on the existing materials, following five basic principles: (1) clarify the nature of knowledge that neuromarketing is based on, (2) explaining the different methods used in it, (3) showing the results obtained with these methods, (4) associating those results with their applications and (5) delving into the impact of the results on the theory or study concepts. In spite of the efforts made by many authors to define neuromarketing (Cruz et al. 2016; Lee et al. 2017, 2018; Lim 2018), a standardized, consensual definition has not been adopted yet by a relevant entity in the field. Therefore, this must be a future line of research for academics on neuromarketing. What seems to be more accepted in the literature is the difference between neuromarketing and consumer neuroscience. Although there is no standardised differentiation, it seems more usual among authors to think that consumer neuroscience refers to the academic part of this new discipline, whereas neuromarketing is more closely associated with the use of neuroscientific tools in the business context (Agarwal and Dutta 2015; Harris et al. 2018a, b).

Possible generalization of the results obtained from neuromarketing

One of the main limitations of works on neuromarketing is the use of small samples in empirical studies, which diminishes the reliability of results and prevents academics from generalizing their findings to the population in general (Plassmann et al. 2015). This limitation has led to studies such as that of (Falk et al. 2012). The authors tried to extrapolate the results derived from the neuronal response of a small number of people to the general population. To that end, they carried out fMRI-based experiments with a group of individuals to measure their neuronal response to three different spots promoting a telephone quitline, as

well as a self-administered survey to measure the effectiveness of the advertisements. These data were compared to the volume of calls received one month preceding and one month following the campaign was launched. According to the results, it was concluded that the neuronal response predicted the population's response to a greater extent than the questionnaires. For this reason, (Falk et al. 2012) suggested a potential connection between a determined group's neuronal findings and the population's response in general.

Using consumer neuroscience as a validation of the existing theories in the literature on consumer behaviour

A future line of work in the context of consumer neuroscience proposed by several authors is to refute traditional consumer behaviour theories using the new tools provided by this discipline (Hubert 2010; Agarwal and Dutta 2015). In addition, new theories on consumer behaviour could be created based on the findings of the experiments (Agarwal and Dutta 2015). This line of work results from the fact that, up until now, the usual practice in the field of consumer neuroscience/neuromarketing is to observe the neuronal activity of individuals exposed to specific stimuli and then justify the results based on the traditional theories on consumer behaviour. Nevertheless, studies have not been made with the purpose to refute or test if the brain activity observed confirms a concrete traditional theory or not.

Integrating emotions in consumer behaviour by means of neuromarketing/consumer neuroscience

In the traditional theory on consumer behaviour, emotions had played a secondary, mainly psychological role (Hubert 2010), especially given how difficult it is to study and understand them. Having said that, emotions have become extremely important in the study of consumer behaviour thanks to neuromarketing and consumer neuroscience. These new disciplines will allow emotions to play an essential role in explaining behaviour, such as economic behaviour (Hubert 2010), or social behaviour, such as blood donation (Martín-Santana et al. 2019).

Applying neuromarketing/consumer neuroscience in the field of social marketing

As has been proven throughout the review, there is a number of topics that neuromarketing was applied, although it is equally true that a lot of terrain has not yet been explored. This is the case with social marketing, especially for the non-profit sector, where this discipline could be greatly helpful. Thus, (Harris et al. 2018b), in their revision on public health and publicity campaigns, mentioned that research has proven that consumer neuroscience and the use of neuroscientific techniques can be more appropriate for non-profit health communications and social causes than for for-profit organizations. This is significant because, by applying neuromarketing, it is possible to understand the stimuli that cause negative reactions to sensitive topics such as blood donation (Romero-Domínguez et al. 2019). That is why (Romero-Domínguez et al. 2019) suggest in their work that blood transfusion centres could, through neuroscientific tools, pre-test their promotional campaigns. This would allow them to guarantee the effectiveness of the campaigns and successfully influence population behaviour concerning blood donation.

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The authors declare that they have no conflict of interest.

Availability of data and material
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Code availability
Not applicable.

Ethics approval

Ethics approval was not required for this research.

Authors' contributions
LRC and JDMS contributed to the study conception and design, material preparation, data collection and analysis, and writing (draft preparation, review and editing). Both authors read and approved the final manuscript.

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