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Review

Consumer Neuroscience Techniques in Advertising Research: A Bibliometric Citation Analysis

Juan Sánchez-Fernández [1], Luis-Alberto Casado-Aranda [1,*] and Ana-Belén Bastidas-Manzano [2]

[1] Department of Marketing and Market Research, University of Granada, 18010 Granada, Spain; sanchezf@ugr.es
[2] Marketing and Tourism Department, Madrid Open University, Collado Villalba, 28400 Madrid, Spain; anabelen.bastidas@udima.es
* Correspondence: lcasado@ugr.es

Abstract: The limitations of self-report techniques (i.e., questionnaires or surveys) in measuring consumer response to advertising stimuli have necessitated more objective and accurate tools from the fields of neuroscience and psychology for the study of consumer behavior, resulting in the creation of consumer neuroscience. This recent marketing sub-field stems from a wide range of disciplines and applies multiple types of techniques to diverse advertising subdomains (e.g., advertising constructs, media elements, or prediction strategies). Due to its complex nature and continuous growth, this area of research calls for a clear understanding of its evolution, current scope, and potential domains in the field of advertising. Thus, this current research is among the first to apply a bibliometric approach to clarify the main research streams analyzing advertising persuasion using neuroimaging. Particularly, this paper combines a comprehensive review with performance analysis tools of 203 papers published between 1986 and 2019 in outlets indexed by the ISI Web of Science database. Our findings describe the research tools, journals, and themes that are worth considering in future research. The current study also provides an agenda for future research and therefore constitutes a starting point for advertising academics and professionals intending to use neuroimaging techniques.

Keywords: bibliometric research; consumer neuroscience; advertising research; emerging trends; neuroimaging tools; consumer behavior

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1. Introduction

Business and advertising research has traditionally turned to self-report methods, namely surveys, focus groups, and interviews, to evaluate, understand, and predict consumer behavior when exposed to advertising [1–3]. These techniques capture conscious expressions, feelings, and verbal-language-based responses from consumers regarding advertising recall, brand awareness, or purchase intentions. Although they are commonly preferred by marketers because of their ease of use, accessibility, and cost-effectiveness, they are subject to bias. They are vulnerable to subjectivity and social desirability, may contain delicate questions (e.g., on sexual or religious orientation), do not measure deeper emotions (e.g., ambiguity, risk), may not be able to apprehend cognitive and affective processes, and do not facilitate the moment-by-moment collection of data [4].

Deficiencies in measuring consumer behavior in self-report tools have led to the search for more precise techniques from psychology and neuroscience to complement traditional market research methods. The combination of techniques from marketing, neuroscience, and psychology has fostered the creation of a new field of marketing called consumer neuroscience, which overcomes most of the limitations of traditional tools [5,6]. This interdisciplinary arena is defined as " ... the study of the neural conditions and processes that underlie consumption, their psychological meaning, and their behavioral consequences" [7]. In practice, a consumer neuroscientific experiment consists of indirectly measuring the subject's neural activation in reaction to a particular marketing feature (e.g., visual advertising)

using neuroimaging techniques and/or other types of psychophysiological methods to identify the brain mechanisms experienced during consumer decision-making [7].

Mounting studies in the area of marketing research have applied neuroimaging techniques to identify the neural origin of consumer decision-processes in the context of product packages [8,9], price [4], advertising [10–12], branding, and e-commerce environments [13,14]. By doing so, these studies have offered important assistance to (1) evaluating consumer reactions in real-time without relying on subjective self-reports; (2) localizing neural correlates of consumer behavior constructs (such as value, fear, reward, trust, persuasion, or memory), that is, where they reside in the brain; (3) capturing hidden processes through brain imaging data (inaccessible through self-reports); and (4) identifying the antecedents and consequences of consumer behavior constructs.

The remainder of this paper is structured as follows: Section 2 presents the new field of consumer neuroscience and its importance in advertising research. It then advances the frame of the current paper as well as the main research questions to be addressed. Section 3 then describes the bibliometric analysis and co-citation steps applying Scimat software and data analysis procedures. Section 4 describes the evolution, journals, and main themes of consumer neuroscience and advertising research before entering into discussion and limitation sections. The study then concludes with a presentation of the findings' main theoretical and practical implications for future research.

1.1. The Value of Consumer Neuroscience in the Field of Advertising Research

One of the branches of marketing that has received the most attention from psychological and neuroimaging studies is advertising. The use of psychophysiology, psychophysiology refers to the branch of psychology exploring the physiological bases (i.e., body reactions) of psychological processes (i.e., brain states) [15], techniques to examine consumer psychological responses toward advertising is not new. This type of research has involved skin conductance (to measure autonomic nervous system excitement triggered by emotional advertising), electromyography (to measure microscopically the controlled and uncontrolled facial muscle movements), electrocardiography (to measure electrical heartbeat activations using external skin electrodes), or eye-tracking (to record eye fixation and changes in pupil dilation and contraction, direct indications of levels of attention) in advertising-related experiments since the 1980s [15–19].

The advances in non-invasive human brain imaging techniques have facilitated the collaboration of economists, psychologists, and neuroscientists to assess the biological foundations of advertising theories. Here, we followed a line of a number of neuromarketing scholars [13,20] in that the only techniques considered to serve to offer objective evidence of neural processing of advertising in the arena of consumer neuroscience are those recording modifications in electrical (electroencephalography (EEG) or magnetoencephalography (MEG)) or metabolic neural activity in the brain (functional magnetic resonance imaging (fMRI) or functional near-infrared spectroscopy (fNIRS)).

Neuroimaging methods offer non-invasive means of monitoring neurocognitive responses to advertising elements. They also allow recording implicit mechanisms potentially involved in the processing of advertising, which is different from self-reported information [21]. In other words, neuroimaging helps to analyze the neural roots of the advertising effects (e.g., reward or self-relevance) triggered by diverse audiovisual elements (e.g., frame, colors, and voice). Neuroimaging in advertising research can therefore help (1) pinpoint the neural correlates advertising constructs (e.g., memory, attention, persuasion, and emotion), (2) determine the nature and dimensionality of advertising effectiveness based on neural correlates and predictors, (3) identify the moderating role of the audience's characteristics (e.g., sex, age, or consumer involvement) when evaluating advertising processing, and (4) assess the antecedents and consequences of advertising constructs (e.g., persuasion). Figure 1 highlights the value of neuroimaging in the field of advertising.

The use of neuroimaging tools in the field of advertising, however, has a number of well-documented methodological, theoretical, and ethical limitations. These include cost,

time to complete a study, artificial research environment, caution with the type of questions that these techniques can address, and concerns over participant autonomy and privacy (for a review, see [22]).

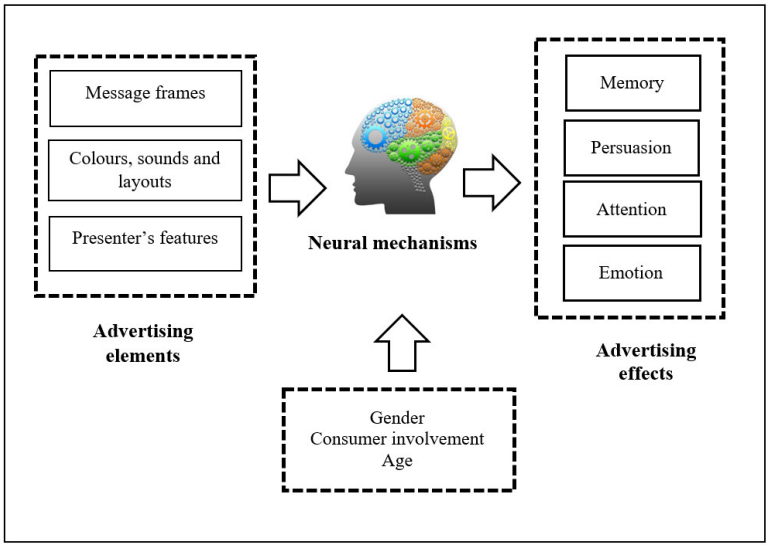


Figure 1. Illustration highlighting the value of neuroimaging in the field of advertising research. Source: Own illustration.

1.2. Main Neuroimaging Tools Applied to Advertising Research

The most commonly used neuroimaging techniques in advertising are EEG, MEG, fMRI, and fNIRS. Particularly, EEG is a non-invasive technique that records the frequency of the brain's electrical currents through electrodes placed on the scalp. Electroencephalography provides high temporal resolution (250–400 ms) but low spatial resolution (approximately 1 cm^3) as it is limited to recording cortical brain activity. Decision-making literature has associated the frequency content (indexed by delta, theta, alpha, or beta bands) of brain waves in the frontal, parietal, and occipital areas to consumer preferences, attention, and memory. MEG is analogous to EEG but records the magnetic fields produced by brain electrical currents using magnetometers. MEG has greater spatial localization recording of deeper brain structures than EEG and an acceptable temporal resolution.

fMRI, in turn, is a non-invasive tool that detects brain changes in the blood level (namely, the fMRI's blood oxygen level dependent, BOLD, signal), derived from metabolic changes in blood flow produced by neural activation. This is achieved using an MRI scanner. fMRI researchers usually compare activity levels within a region of interest across different task conditions. As different regions of interest are attributed through specific inferences to particular mental functions (e.g., persuasion or attention [23]), they are able to identify the neural origin of mechanisms triggered by message elements while visually representing and localizing this result through MR brain images [24]. The fMRI is exceptional in assessing specific brain areas with a high resolution (1 mm^3) and provides an acceptable temporal resolution (1–3 s).

fNIRS is an innovative recent noninvasive optical imaging tool that records modifications in hemoglobin (Hb) flow within the brain through absorption spectra of Hb in the near-infrared range. The spatial resolution and penetration depth of fNIRS images is up to 2 cm, making it appropriate for monitoring brain areas located in the prefrontal cortex, a brain region that is pivotal in advertising preferences [25]. Figure 2 summarizes the four most-used neuroimaging tools in advertising research.

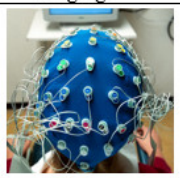
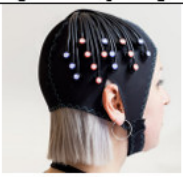
Neuroimaging technique	Measure of brain activity	Technology
 Functional Magnetic Resonance Imaging	Detecting changes in the oxygenation level of the blood and visualizing this result through brain images that evidence the contrasts of activity between brain regions.	MRI scanner inside which the subject lies during the time of the experiment.
 Electroencephalography	Measures of the frequency of the brain's electrical currents and changes in voltage via electrodes placed on the scalp	Electrodes spread on the subject's head (usually 64 sensors)
 Magnetoencephalography	Measures magnetic fields produced by electrical currents occurring naturally in the brain	Very sensitive detectors of the small magnetic field of the brain, called SQUID (superconducting quantum interference devices)
 Functional near-infrared spectroscopy	Records changes in hemoglobin (Hb) concentrations within the brain through an absorption spectrum of Hb in the near-infrared range	Electrodes spread on the subject's head

Figure 2. Illustration highlighting the value of neuroimaging in the field of advertising research. Source: Own illustration.

The application of these neuroimaging techniques to advertising research started in 1986. Rothschild et al. [26] used EEG for the first time to measure changes in electrical neural activity while participants were exposed to television commercials. Their results showed correlations between the level of EEG activity and several measures of learning and affect. Henceforth, worldwide researchers and professionals applied neuroimaging techniques to extend traditional advertising research theories to better understand consumer reactions in advertising and to improve the effectiveness of communication campaigns. Along this line, a wide range of advertising studies have applied fMRI, EEG, MEG, and fNIRS to assess the neural correlates of constructs serving as indicators of advertising message persuasion, particularly emotion, attention, preference, and memory [27,28] to explore neural predictors of communication-relevant outcomes [11,29], or to evaluate the neural processing of media elements included in advertising [30,31]. However, the understanding of how these techniques are applied to different advertising subdomains remains unclear in the academic literature. Additionally, no investigation to date has evaluated the whole corpus of research applying neuroimaging techniques in the advertising domain, the relative importance of neuroscientific techniques in advertising research, or the most-investigated themes and research streams. Hence, reflection on the field as a whole would serve to clarify the evolution, current scope, and further subthemes of interest in neuroimaging techniques in advertising research.

1.3. The Current Study

We, therefore, aimed to fill this gap through a bibliometric analysis of published articles applying neuroimaging in advertising research. This approach is valuable as

consumer neuroscience derives from a wide range of disciplines and applies multiple techniques to a wide diversity of advertising subdomains. Due to the complex nature and continuing advances in this arena, we conducted an interdisciplinary review of the literature addressing four research questions:

- **RQ1**: How have advertising research publications that used neuroimaging evolved?
- **RQ2**: Which neuroimaging tools are the most common in advertising studies?
- **RQ3**: Which are the most-cited journals worth consulting for future research in this field?
- **RQ4**: What are the underlying research streams, and which deserve further consideration in prospective advertising studies?

This approach outlines future steps for specialists interested in advertising research because it structures, outlines, and identifies the crucial techniques, advertising subdomains, and journals to consider when conducting further neuroimaging research in the field of advertising. This survey, besides offering an overview of the history of research, identifies and blends both traditional and recent streams. Therefore, the findings offer an easy-to-use guide for advertising scholars and communication professionals interested in the topic of consumer neuroscience.

2. Methodology

We aimed to answer the four research questions by implementing a bibliometric analysis that combined: a comprehensive empirical review of research on advertising research that applied neuroimaging techniques and performance analysis tools. To develop these two phases, we considered the main publications using neuroimaging techniques in the field of advertising research from 1986 to 2019. In the first step, we focused on the number of cites of the publications, the category of the journal in which they were published, neuroimaging techniques/approaches they used, as well as the advertising subdomains of interest. Following the scheme described by Cobo et al. [32], in the second step, we developed quantitative indicators to highlight research topics based on the number of papers and to measure the impact of the detected topics. Together, these approaches helped provide a review of the evolution of the field of advertising research by identifying and visualizing its conceptual subdomains (general and particular thematic areas) and motor themes. Specifically, in both phases, we used a co-word analysis as implemented in Scimat software [32], a tool used to evaluate the conceptual and social scope of a research area. A co-word analysis constitutes a content analysis tool, which is useful for providing an overview of the strength of association among textual items as well as for describing the interactions between diverse areas and themes in academic research [33]. This co-word analysis builds a strategic diagram to help identify the potential research that used neuroscience techniques in the communication arena.

To accurately detect the main themes in the co-word analysis, we followed the stages described by Cobo et al. [32]. This consisted of initially singling out the keywords in the selected publications (i.e., author and journal keywords) as types of items to analyze. The second step was gathering pivotal information from the raw data in a file stemming from the query. As outlined by Cobo et al. [32], these key data were derived from the co-occurrence frequencies of keywords. Individually, the co-occurrence/recurrence of two keywords is extracted from the corpus of files by counting the number of files in which the two keywords appear together. The third phase consisted of calculating the similarities between items considering the information gathered in the previous stage. These analogies were calculated from the keyword co-occurrence frequency. Following the recommendation of Cobo et al. [33], an equivalence index served as the most appropriate measure to normalize the co-occurrence frequency. The fourth stage consisted of conducting clustering to identify the keyword subgroups related to each other that conform to the centers of interest. Following the methodological line suggested by Cobo et al. [32], we used the simple center algorithm and chose 1 and 3 as the minimum and maximum network size,

respectively. Finally, average citations were selected as a quality measure for the strategic diagram.

The strategic diagram developed during the clustering process is based on two criteria [33]: centrality, which refers to the degree of interaction of different networks, so it is a number related to the relevance of a topic within a specific field; and density, which is related to the internal strength of the network, thereby revealing the theme's development. The combination of high and low levels of density and centrality enabled the splitting of the two-dimensional strategic diagram into four groups of themes, as shown in Figure 3.

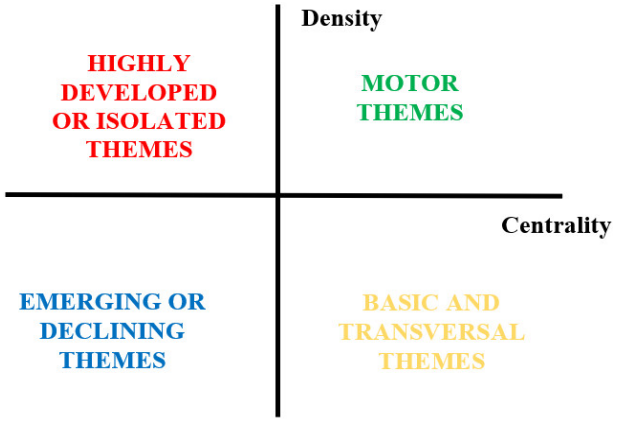


Figure 3. Quadrants in a strategic diagram. Source: Own illustration.

3. Results

3.1. Neuroimaging Techniques in Advertising Research: Evolution and Journals

This section presents the evolution of the use of neuroimaging techniques in the field of advertising research through the number of papers published in consumer neuroscience from 1986 to 2019. We found 203 articles in the selected period after a screening process was applied in Scimat [33] to delete articles strictly unrelated to neuroimaging techniques in advertising environments, including both empirical and theoretical ones. Papers using non-neuroscientific tools (such as biometrics or eye-tracking) were not included in the analysis as they do not directly measure any neuroimaging responses [24]. Our findings highlight the frequent application of neuroimaging techniques within the last five years of the study period in the field of advertising research as well as the potential development of this subfield (Figure 4).

When focusing on the methodological aspects of these studies, 22% provided theoretical reviews of neuroimaging tools and advertising research, while the remaining studies carried out empirical research. Of the total, 44% used fMRI, 30% preferred EEG, 4% chose fNIRS, and only 1% used MEG. We also examined the evolution of the use of these approaches over time. The results in Figure 5 show that fMRI and EEG techniques are starting to gain popularity in advertising studies, with the former tool showing a larger increase in the last four years. Despite reviews playing an important role from 2014 to 2017, they started losing prominence in the last three years.

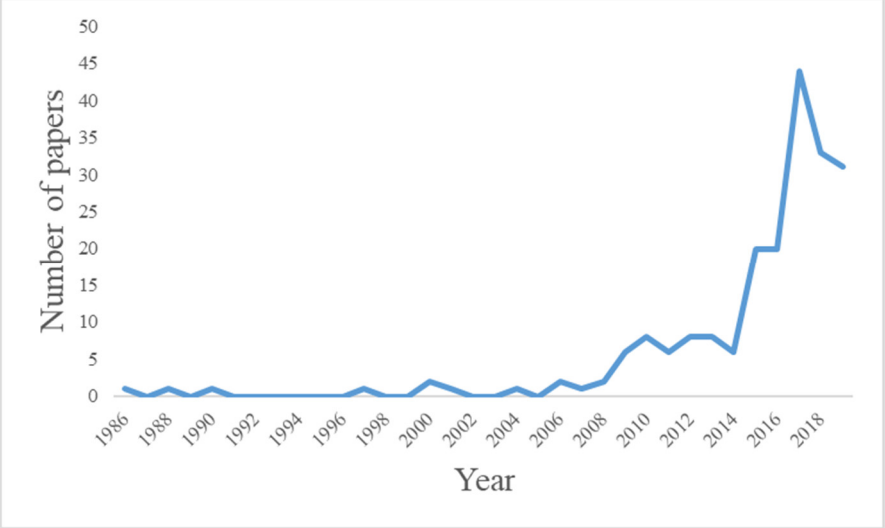


Figure 4. Number of papers in ISIWoS (y-axis) focused on advertising research by means of neuroimaging techniques from 1986 to 2019. Source: Own illustration.

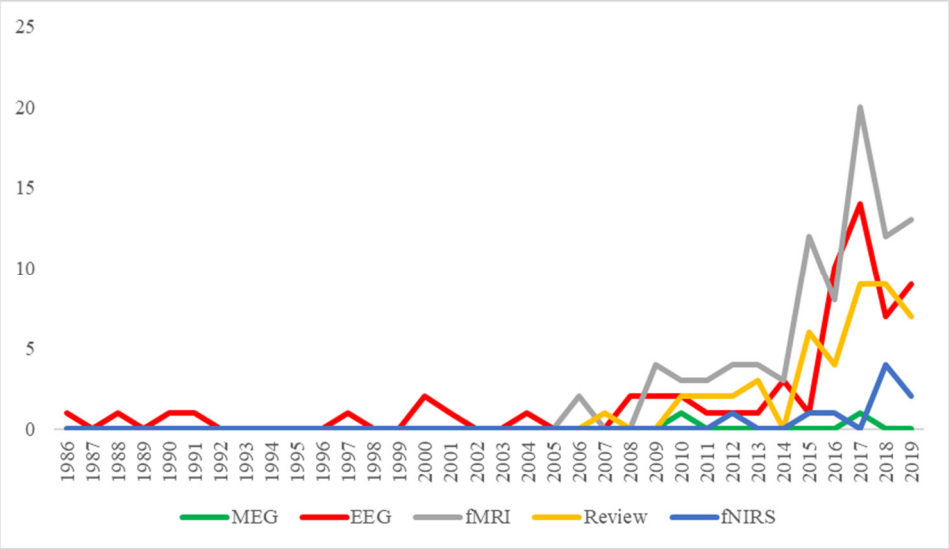


Figure 5. Studies in consumer neuroscience applying fMRI, MEG, EEG, fNIRs, and reviews. Source: Own illustration.

Based on the number of publications, Table 1 lists the most renowned authors that applied neuroimaging techniques in the study of advertising research. Only authors with a minimum of four papers are presented. The American researchers Emily Falk and Matthew Lieberman stand out, with 40 and 17 papers each, respectively. The most productive authors belong to institutions related to neuroscience, psychology, business, and marketing, thus revealing the interdisciplinary nature of consumer neuroscience.

The recent interest in applying neuroimaging tools to advertising research is multidisciplinary. The articles were being published not only in neuroscientific journals (neuroimaging or social cognitive and affective neuroscience) but also, and mostly, in marketing and advertising journals such as the Journal of Advertising Research or the Journal of Consumer Behaviour, as well as in interdisciplinary journals such as Plos One, Journal of Neuroscience, Psychology and Economics, and Frontiers in Psychology Neuroscience. Table 2 and Figure 6 lists the papers using neuroimaging tools in the advertising domain with the highest number of citations.

Table 1. Authors with a minimum of four publications in consumer neuroscience within the analyzed period (1986–2019).

Author	Number of Papers	Author	Number of Papers
Falk, Emily B. (University of Pennsylvania, Annemberg School for Communication)	40	Dore, Bruce P. University of Pennsylvania, Annemberg School for Communication	4
Lieberman, Matthew D. (SCN Lab Director, Harvard University)	17	Sánchez-Fernández, J. (Marketing and Market Research Department, University of Granada)	4
O'Donnell, Matthew Brook (University of Pennsylvania, Annemberg School for Communication)	15	Casado-Aranda, L.A. (Marketing and Market Research Department, University of Granada)	4
Babiloni, Fabio (Sapienza University of Rome)	10	Cartocci, Giulia Sapienza University of Rome	4
Cooper, Nicole (Annemberg School for Communication)	7	Rossi, Dario (Sapienza University of Rome)	4
Cascio, Christopher N (University of Pennsylvania)	6	Vecchiato, Giovanni (National Research Council of Italy)	4
Berkman, Elliot T. (University of Oregon)	6	Vettel, Jean M. (US Army Research Laboratory)	4
Smidts, Ale (Marketing Department, Erasmus Univ, Rotterdam, Netherlands)	5	Fallani, Fabrizio De Vico (Brain and Spine Institute (ICM)	4
Cherubino, Patrizia (Sapienza University of Rome)	5	Astolfi, Laura (Sapienza University of Rome)	4
Maglione, Anton Giulio (Sapienza University of Rome)	5	Tompson, Steven (US Army Research Laboratory)	4

Source: Own illustration from Scimat.

Table 2. Papers with the highest number of citations.

Title	Authors	Year	Citations
Neuromarketing: the hope and hype of neuroimaging in business	Ariely, D, Berns, GS	2010	259
What is 'neuromarketing'? A discussion and agenda for future research	Lee, N, Broderick, AJ, Chamberlain, L	2007	226
Predicting Persuasion-Induced Behavior Change from the Brain	Falk, EB, Lieberman, MD, Berkman, ET, Mann, T, Harrison, B	2010	150
From Neural Responses to Population Behavior: Neural Focus Group Predicts Population-Level Media Effects	Falk, EB, Lieberman, MD, Berkman, ET	2012	117
Neural Activity During Health Messaging Predicts Reductions in Smoking Above and Beyond Self-Report	Falk, EB, Lieberman, MD, Berkman, ET, Whalen, D	2011	106
Beyond Brain Mapping: Using Neural Measures to Predict Real-World Outcomes	Falk, EB, Berkman, ET	2013	106
In the Trenches of Real-World Self-Control: Neural Correlates of Breaking the Link Between Craving and Smoking	Falk, EB, Lieberman, MD, Berkman, ET	2011	96
A brief review on the use of functional near-infrared spectroscopy (fNIRS) for language imaging studies in human newborns and adults	Quaresima, V, Ferrari, M, Bisconti, S	2012	86
Predicting Advertising Success Beyond Traditional Measures: New Insights from Neurophysiological Methods and Market Response Modeling	Venkatraman, V, Dimoka, A, Pavlou, PA, Vo, K, Hampton, W, Bollinger, B, Hershfield, HE, Ishihara, M, Winer, RS	2015	83
Extending Brain-Training to the Affective Domain: Increasing Cognitive and Affective Executive Control through Emotional Working Memory Training	Schweizer, S, Hampshire, A, Dalgleish, T	2011	76
Changes in Brain Activity During the Observation of TV Commercials by Using EEG, GSR and HR Measurements	Babiloni, F, Vecchiato, G, Fallani, FD, Mattia, D, Astolfi, L, Cincotti, F, Salinari, S, Soranzo, R	2010	66

Source: Own illustration from Scimat.

Figure 6. Main journals in which most advertising research using neuroimaging tools has been published. Source: Own illustration.

3.2. Traditional and Emerging Themes in Advertising Research: Neuroimaging Applications

Figure 7 illustrates the findings of the strategic diagram analysis, in which the size of the spheres is proportional to the number of published documents related to each theme. The themes included in the upper-right quadrant—neuromarketing (33), behavior (26), meta-analysis (10), and the technique fMRI (49)—are likely to be further developed from the conceptual perspective and are the driving themes of the advertising research that applies neuroimaging techniques. Therefore, prospective neuromarketing research might focus on using fMRI to predict behavior based on brain regions included in previous and prospect meta-analyses. The themes social influence (10) and preference (6) were the top emerging topics in the field, likely due to the recent interest in investigating how social influence affects the neural processing of advertisements. Terms such as emotion (27) and brand (5) are transversal themes of interest for neuroimaging research in the field of advertising, as investigations have largely evidenced the neural correlates of emotion in advertising, including brands. EEG asymmetry (5) and memory (7) constitute themes traditionally investigated but recently increasing in relevance.

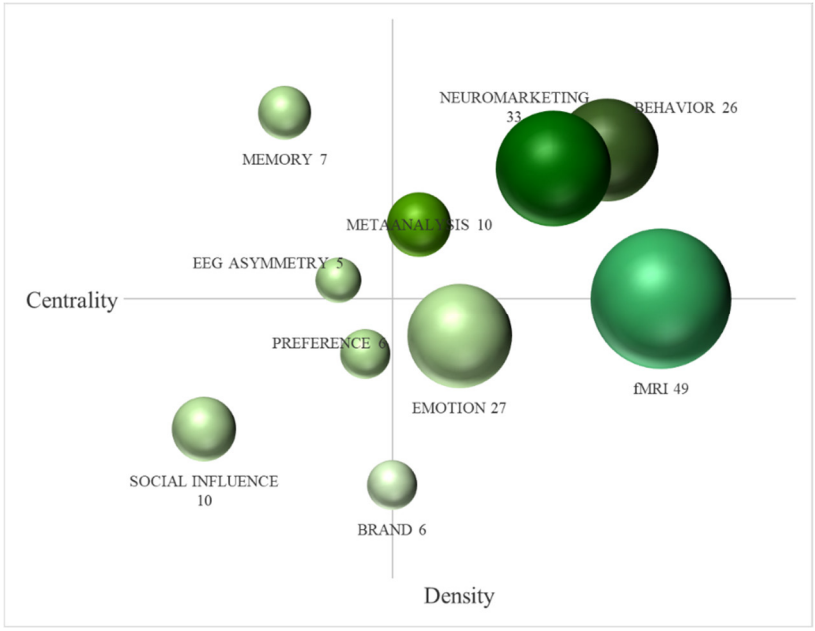


Figure 7. Strategic diagram for the period 1986–2019 based on published documents. Source: Own illustration from Scimat.

3.3. An Overview of Neuroimaging Studies Applied to Advertising Research

To gain insight into the most-explored advertising subdomains in neuroimaging studies, and draw more precise boundaries on the scope of advertising research and the main applied approaches and neuroimaging techniques, we summarized the selected literature review.

3.3.1. Neural Correlates of Emotion, Attention, and Memory

The advertising literature has demonstrated a growing interest in measuring emotions and preferences through the estimation of brain reactions. Particularly, EEG and fMRI experiments have been conducted to identify brain regions involved with the emotional engagement in pleasant advertising. Morris et al. [34], for instance, used fMRI to record neural reactions to TV advertisements using a three-dimensional construct scale (namely arousal, pleasure, and dominance). Applying Advertisement Self-Assessment Manikins as a model for fMRI data, the authors associated frontal and temporal brain regions to pleasant and arousing advertising. More recently, Feng and Morris [35] offered a central method merging a visual self-reported scale with fMRI to record emotional reactions to TV advertisements. They identified brain reactions to emotions in advertising, thus revealing the relevance of the three key dimensions of emotion in recording sentiments about advertisements. Similarly, Vecchiato et al. [36] measured EEG responses while participants watched TV commercials. Their results showed frontal areas in the alpha band when visualizing TV ads previously reported as pleasant. Other studies [37] evaluated emotional responses to visual and communication elements using EEG and found that positive frontal alpha asymmetry was experienced when the participants judged the visual art stimuli as either beautiful or not beautiful. These authors found more positive emotional reactions to the visual art stimuli irrespective of their aesthetics. Chang-Hee et al. [38] explored whether applying the global field synchronization index (GFS index, an index that correlates with cognitive mechanisms) to the EEG can be used to record modifications in emotional arousal during video-viewing. Their results showed that the GFS index could be used as an index for identifying emotional arousal modifications during video watching. Several studies using fNIRS evaluated preference in advertising settings and concluded that orbitofrontal cortices are engaged in emotional and preferred commercials [25,39].

EEG constitutes the neuroimaging technique that offers advertisers a trustworthy tool to categorize top-down and bottom-up attention in advertising. In EEG investigations into advertising, occipital alpha reactions have been associated with attention processes, namely visual engagement during TV commercials [26,40]. Shestyuk et al. [41] further assessed whether TV attention and Twitter interactions can be predicted using EEG. As expected, their findings showed that the EEG measures correlated with the two behavioral measures of TV attention and Twitter volume. Previous fMRI research reported a negative correlation between attention toward public advertisements, evidenced by occipital activity, and certainty in recognition, thus revealing that the attention-grabbing visual content of advertisements could bar the retention of information [27]. A recent fMRI investigation found that sex-congruent (vs. incongruent) product–voice combinations evoke brain areas involved with endogenous attention [12]).

The first study using EEG to explore neural reactions of visual memory encoding with regards to visual advertising was [42]. The authors concluded that the short- to long-term memory transfer of information from TV advertisements is located in the left-brain hemisphere. Smith and Gevins [40] used EEG in participants who viewed television commercials to explore whether manipulations of semantic content, namely the inclusion of humorous items, provoke differences in posterior cortical regions associated with executive processes. More particularly, the authors concluded that the power of a posterior-distributed alpha component provokes frontal lobe elicitation involved with episodic memory encoding. Shestyuk et al. [43] and Astolfi et al. [44] assessed the neural mechanisms triggered by successful memory-encoding of TV commercials. Aligning with previous studies, these researchers corroborated that successful encoding of TV commercials influences the functional communication among cortical areas regardless of the frequency band. Morey [45] further evaluated the effects of message typology (negative or positive) on recognition memory for political candidates using EEG (indexed as brain electrical activation in the gamma band frequency range). The direct effect of gamma on memory highlighted the potential of using EEG in the study of message processing. Along the same line, several fMRI studies [45–47] found greater amygdala and fronto-temporal activity for memorable versus unmemorable ads.

3.3.2. Neural Predictors of Communication Campaigns

Although persuasive ads often modify the audience's self-reported perceptions to develop behaviors, such self-reports do not necessarily derive behavior change. Neuroimaging studies have recently demonstrated the ability of brain reactions to persuasive communications to forecast behavior modifications beyond the variance predicted by self-reported responses. Several fMRI studies in the field of health communications have shown that increased activity in the amygdala, a brain area related to affective processing, predicts both quit intentions and population-level information-seeking; this was mediated by activation in the ventromedial prefrontal cortex, an area associated with value computation [11,29,48]. Similar brain patterns were found in sunscreen use [49] and alcohol-quitting behaviors [50]. Further fMRI studies found that the temporal lobe and cerebellum predict out-of-sample preference and recall toward broadcasted TV commercials [51]. Recent fMRI research has been directing attention to exploring the social influence mechanisms in the processing of advertising, strongly supporting the ability of neural information to forecast real-world behavioral performs beyond the imaging tools [52,53].

EEG experiments have also been used to predict consumers' decision-making in advertising settings. The study by [8], for example, concluded that the extracted measures from EEG predict consumer decisions with high accuracy (>87%), and differentiate between positive and negative preferences toward ads, with an accuracy of >63%. Along the same line, Shestyuk et al. [54] assessed whether the persuasion of TV Super Bowl ads on YouTube can be predicted using neural EEG records. Their results showed a correlation between EEG metrics and self-reported ad effectiveness and the direct number of views on the

YouTube channel. Other studies [4,55,56] arrived at similar conclusions and corroborated that EEG measures are related to real-world outcomes.

3.3.3. Neural Processing of Message Features: Sustainability and Political Ads

Neuroimaging can also assist in assessing the effectiveness triggered by ad elements, as certain brain regions are associated with specific cognitive and affective processes (e.g., reward or attention). Extensive research has evaluated the neural mechanisms triggered by different categories of sustainability and environmental advertising, namely gain- or loss-framed, political, voice effects, or functional vs. experiential ads. For example, Casado-Aranda et al. [30] conducted an fMRI study to reveal the neural effects of message framing and voice sex in sustainability commercials. Their conclusions showed that the male voice not only conveys stronger attitudes toward ecological advertisements, it also engages brain areas associated with content–format integration and reward. Consequently, the authors recommend that managers that target environmentally sustainable services and goods, as well as environmental institutions, use male voices coupled with gain framing in environmental advertising. Casado-Aranda et al. [57] were also interested in revealing brain reactions to persuasive sustainable advertising that differs in temporal framing and in the age of the voice presenting them. Their results not only report higher attitudes toward future-framed messages (e.g., "If society does not act now, the effects of climate change will soon become real") spoken by young voices, but brain regions involved with relevance and value are more strongly elicited by young voices and ecological messages about the future. Vezich et al. [58] exposed participants in an fMRI to sustainability and standard ads. Ratings were more favorable for green ads than for control ads, but the functional MRI data suggested an opposite pattern: participants showed greater activation in regions associated with personal value and reward (ventromedial prefrontal cortex and ventral striatum) in response to control ads relative to green advertisements.

More recently, Medina et al. [59] assessed the differences in price processing among consumers adopting sustainable habits (prosocial) as opposed to those who have not (non-prosocial). Their findings showed that non-prosocial (vs. prosocial) consumers exhibit greater activation in brain areas involved with reward, valuation, and choice when evaluating price information. Other studies [60] used neuroimaging to explain how environmental priming can increase consumer preferences for fashion products with green logos and advertising. Their results corroborated that brain activations in the superior parietal lobule and the bilateral lingual gyri are found during green-related communication, reflecting the brain processes of relational reasoning, leading to increased preference for fashion products that bear a green logo. Shestyuk et al. [61] assessed the neural responses to functional and experiential ads using fMRI and found that these typologies are differently processed in brain networks related to lower- and higher-level cognitive mechanisms. Chua et al. [62] further clarified the neural correlates of high- and low-tailored (healthy) smoking cessation messages. Their results showed that high-tailored (vs. low) messages strongly elicit brain activations implicated in self-related processing. Seeling et al. [47] found that low message sensation value (MSV) ads, that is, those with a low sensory intensity of the audiovisual and content figures, are better remembered and produce more prefrontal and temporal and less occipital cortex activation, suggesting that high MSV may divert cognitive resources from processing ad content.

Political advertising research has recently applied neuroimaging to evaluate the neural mechanisms of attitudes toward politicians. Spezio et al. [63], for example, displayed images of losing and winning politicians to participants in a fMRI, while assessing which looked more competent, attractive, and threatening. Neural data revealed that when negative portrayal was enhanced, images of losing politicians provoked stronger activity in areas associated with negative and risky feelings. Their results thus showed that negative portrayals based on appearance exert greater effects on voting than positive portrayals. Further studies ([64–66]) have explored the neural mechanisms underlying the processing of positive and corruption-based political advertising. Along the same

line, Schmälzle et al. [22] evaluated the neural processing of rhetorically weak or powerful political speeches and found stronger activation in the superior medial prefrontal cortex and temporal gyri elicited by powerful speeches, thus revealing that suggesting that these are more persuasive in taking control of the listeners' brain responses.

4. Discussion

The limitations of self-report techniques in measuring consumer response to advertising stimuli necessitated the construction of more objective and accurate tools in the fields of neuroscience and psychology for the study of consumer behavior, resulting in the creation of consumer neuroscience. This recent marketing sub-field stems from a wide range of disciplines and applies multiple types of techniques (e.g., fMRI, EEG, MEG, or fNIRS) to diverse advertising subdomains (e.g., advertising constructs, media elements, or prediction strategies). Due to its complex nature and continuous growth, this area of research requires a clear understanding of its evolution, current scope, and potential domains in the field of advertising. Several review papers attempted to fill this gap. For instance, Solnais et al. [24] conducted a semantic cluster analysis of the limitations of the consumer neuroscience field using an empirical review limited to 34 studies, with no specific focus on advertising. Other studies analyzed the research of neuromarketing applied to consumer behavior through an integrative literature review and revealed the main brain areas to be considered in future research [9,67]. Several studies outlined the importance of neuroimaging studies and tools for business managers and researchers [9,68,69]. Others [23] explained the potential of neuroimaging for advertising researchers. However, scarce attention has been paid to the relative importance of neuroimaging tools in advertising research, the most investigated advertising subdomains and journals, as well as the lack of an approach to detect, quantify, and visualize the main themes of advertising research that applies neuroimaging. The current paper takes a step forward and constitutes the first to develop a bibliometric analysis to fill this research gap through a comprehensive empirical review combined with performance techniques. Unlike previous studies, this research reveals, for the first time, the evolution of the application of neuroimaging in advertising research (with a strong increase between 2010 and 2019), as well as the main research tools (mainly fMRI and EEG), journals (interdisciplinary outlets), and themes (neural correlates of emotion, attention, and memory; neural predictors of communication campaigns; and neural processing of measure features) that are worth considering in future research.

Particularly, we identified 203 theoretical or empirical articles published between 1986 and 2019 that performed advertising research using neuroimaging techniques, namely fMRI, EEG, MEG, or fNIRS. The results of the bibliometric analysis help answer RQ1 regarding the evolution of the subject. The number of advertising-related papers focusing on neuroimaging increased considerably between 2010 and 2019. The comprehensive empirical review offers a response to RQ2: the articles identified fMRI and EEG as the most common tools. The use of fMRI has significantly increased in the last three years compared to EEG. These findings align with those of previous research emphasizing the advantages of fMRI over other neuroimaging techniques, as fMRI is non-invasive and able to cover most of the deeper brain structures where the main decision-making processes occur [23,70,71]. No less important and linked to RQ3, we identified the most widely explored advertising subdomains, as well as the journals most commonly cited and thus of interest to advertising research. The results of the bibliometric analyses highlight the worldwide distribution of the most outstanding journals in this research arena. The data also offer information on the international distribution of the most outstanding academic outputs and journals in this area of research. The findings regarding the most common journals corroborate the interdisciplinarity characteristic of the field of consumer neuroscience, showing the higher predisposition of marketing journals to accept papers on neuroimaging methods.

The co-word analysis conducted using Scimat software [32] enabled performance examinations to detect, quantify, and visualize the contribution of themes to the whole research field (RQ4). The analysis of the strategic diagram spanning all the consumer neuro-

science research revealed that neuromarketing, behavior, meta-analysis, and the technique fMRI are the driving themes, that is, the most compelling and highly developed themes currently in the field of advertising research that applies neuroimaging tools. Streams such as social influence and preference are likely to play an important role in future neuroimaging studies due to their emerging position. Most importantly, the findings highlight that traditional EEG asymmetry and memory themes have increased in importance in recent years. Thus, prediction and identification of the neural correlates of social influence while online consumers process advertising are future lines of research. Emotion and brand are still transversal topics in consumer neuroscience publications.

5. Conclusions

5.1. Implications for Theory and Practice

Theoretically, the current findings contribute to the line of thought challenging the relevance of neuroimaging in the evaluation of advertising persuasion. For the first time, this research reflects: (1) the typology of neuroimaging studies developed in the field of advertising in general, and sustainable in particular; and (2) a synthesis of the elements of advertising to which more attention has been paid from the perspective of neuroimaging. Particularly, to gain insight into the most-explored advertising subdomains in neuroimaging studies, we detected the main research streams in neuroimaging studies in the field of advertising. More specifically, studies have focused on revealing the neural correlates of key constructs in message effectiveness, such as emotion, attention, and memory. Another line of research has investigated the ability of neural responses to predict behavior after persuasive campaigns. Other studies, in turn, have explored the neural processing of message features, such as sex of the voice, political messages, or message framing (Table 3). Together, the lines of research identified here should form the basis for further analysis of the neural effects of different types of communication on consumer behavior.

The findings of the bibliometric study should be considered in communication campaign strategies adopted by firms, as they highlight the type of communication that is most persuasive from a neural point of view. Specifically, the results of neuroimaging studies corroborate that the activation of frontal brain areas is related to a greater value, reward, and persuasion associated with communicative stimuli. Occipital brain areas have been related to attentional processes and certainty in recognition. Therefore, those communication campaigns that provoke frontal and occipital neural experiences will be more persuasive. Other studies have corroborated that the amygdala and the frontal ventromedial cortex constitute cerebral areas capable of predicting the persuasion of communication campaigns. More importantly, research in the field of sustainable advertising corroborates that the use of a young male voice, presenting messages that emphasize the future consequences of acting responsibly, is the most persuasive combination of elements from a neural point of view.

Table 3. Overview of main research streams and topics in consumer neuroscience and advertising.

Main Research Stream	Main Topics and Message Features	Studies
Neural Correlates of Emotion, Attention, and Memory		
Emotion	• Neural responses to arousal, valence, and dominance in advertising • Alpha asymmetry during pleasant stimuli • Brain activations toward preferred commercials and videos	• Morris et al. [34]; Shen and Morris [35]; Chang et al. [31] • Vecchiato et al. [36]; Cheung et al. [37] • Burns et al. [39]; Krampe [25]
Attention	• EEG alpha reactions to attentional processes toward TV commercials • Brain reactions toward recognized and relevant advertisements	• Rothschild et al. [26]; Smith and Gevins [40]; Shestyuk et al. [41] • Langleben et al. [27]; Casado-Aranda et al. [14]
Memory	• Short- and long-term memory through EEG • Brain regions associated with visual and executive processes when visualizing diverse semantic content • Brain networks related to memorable vs. non-memorable advertising	• Rossiter et al. [42] • Smith and Gevins [40]; De Vico Fallani et al. [43]; Astolfi et al. [44]; Morey [45] • Bakalash and Riemer [46]; Seelig et al. [47]
Neural predictors of communication campaigns		
Health communication	• Neural predictors of persuasive health communications (smoking cessation or sunscreen use)	• Doré et al [48]; Falk et al. [11,29]; Burns et al. [49]; Courtney et al. [50]
Social influence	• Social influence mechanisms in the processing of advertising	• Cascio et al. [52]; Kuss et al. [53]
EEG accuracy to predict preference	• Prediction of TV commercials effectiveness by means of EEG	• Golnar-Nik et al. [8]; Guixeres [54]; Deitz et al. [56]; Venkatraman et al. [4]
Neural processing of measure features		
Message contents	• Neural processing of sustainable and political ads: loss vs. gain; future vs. past; young vs. old voice; male vs. female voice; high and low tailored messages	• Casado-Aranda et al. [6,14,21]; Medina et al. [59]; Lee et al. [60]; Seelig et al. [47]; Couwenberg et al. [58]; Chua et al. [59]
Political messaging	• Candidates images; positive vs. corruption messages; weak vs. powerful political speech	• Spezio et al. [60]; Casado-Aranda [61]; Schmälzle et al. [22]

Source: Own illustration.

5.2. Limitations

Although the dataset from the ISI Web of Science is comprehensive and is not restricted to specific journals (e.g., business, management, or psychology), it is not exhaustive. Bibliometric studies can be subjective as they require choices to be made as to the timeframe and terminology, as well as identifying the core research streams. For example, papers tangentially approaching advertising research that did not include the key terms used for the search may have been missed by the current analysis. Along the lines of previous research [24], we decided to only include papers applying neuroimaging techniques, omitting biometrics or eye-tracking research tools. Further research may replicate this analysis by considering only psychophysiological methods. The articles reviewed in this survey were all published in English. Future research should investigate research published in other languages to highlight their contribution to the field. Notably, the ISI Web of Science database is currently maintained by Clarivate Analytics, which has integrated the Web of Science service with the ISI Web of Knowledge.

5.3. Avenues for Future Research

5.3.1. Neural Activity as a Predictor of Behavioral Changes

The most recent studies in neuroimaging and advertising demonstrate the ability of neural responses to predict changes in consumer behavior, beyond self-reported results [48]. This procedure is being applied to evaluate the effectiveness of health-related messages (such as tobacco or sunscreen use [50]) as well as the effect of peer influence on the effectiveness of advertising [53]. Although neural activations have been shown to be a predictor of behavioral changes, further efforts are needed in several areas in advertising and business research, for example, evaluating the capacity of neural responses triggered by sustainable advertising to predict ecological purchases. It would also be of interest to assess whether the neural response associated with messages promoting responsible online game behaviors are useful in predicting modifications in online gaming behaviors. Given the recent growth in online shopping and the automatic nature of decisions in this purchase context [14], a future area of research may explore the predictive ability of neural responses associated with web-based communication elements (such as seals of approval or hedonic vs. utilitarian items) to forecast online shopping attitudes or behaviors. Some potential research questions include the following: (1) To what extent do neural responses associated with gain vs. loss messages that promote responsible habits predict changes in recycling levels? (2) To what extent do the warnings about the time played provoke brain activations that manage to predict the reduction in the amount of the online bets? (3) Do the brain's responses associated with rating systems forecast increased online shopping intentions and behaviors?

5.3.2. Neural Correlates of Persuasion: Understudied Types of Messages

Other research in the field of neuroimaging has consistently evaluated the neural correlates of attention, emotion, and persuasion linked to a multitude of message typologies, such as corruption vs. positive political items, loss vs. gain, future vs. past, and high- vs. low-tailored (e.g., [57,58] or [22]). No investigation to date, however, has explored the neural correlates of persuasion in messages that promote individual responsibility in emergency situations, such as the COVID-19 pandemic [72]. Further, the extent to which hedonic vs. utilitarian, sexual vs. non-sexual, sustainable vs. unsustainable, or assertive vs. non-assertive messages (e.g., [73]) trigger brain activations implicitly related to persuasion has not yet been clarified in the present body of literature on neuroimaging and advertising. When addressing the above-mentioned issues, an important research step will be clarifying the neural origin of the preference and persuasion of various message types.

5.3.3. Complementarity of Consumer Neuroscience Techniques in Advertising Evaluation

The current bibliometric study demonstrated the ability of several neuroimaging techniques to assess and predict the persuasion of different types of messages. However, as shown in Figure 5, the use of the fNIRS technique is still in its early stages, so future research should corroborate the usefulness and reliability of this tool in the field of advertising. Psychophysiology methods considerably contribute to the field of advertising. Despite their application being more consolidated than neuroimaging techniques, it would be advisable to use them as a complementary resource to the results obtained with neuroimaging techniques. Note that unlike neuroimaging techniques that evaluate brain responses, psychophysiology responses evaluate the physiological bases (i.e., body reactions) of psychological processes. Hence, autonomic nervous system excitement, electrical heartbeat activations, or eye fixation changes measured by skin conductance, electrocardiography, or eye-tracking, respectively, can be useful to corroborate the results obtained by neuroimaging techniques in further research.

5.4. General Conclusions

Despite the recent increase in studies applying neuroimaging techniques to explore consumer reaction to advertising stimuli, most studies surprisingly omitted an overview

of the evolution, current scope, and potential domains of interest for consumer neuroscience. In the present study, we identified key areas in (sustainable) advertising research applying neuroimaging techniques, the structure of the thematic networks of the research themes in the academic literature, and important insights that can shape future research. Particularly, this is the first bibliometric study to identify the research tools, journals, and, most importantly, the conceptual subdomains and driving themes that will play an important role in further research in the field of advertising persuasion assessed through neuroimaging. Therefore, this bibliometric study constitutes a starting point for academics and professionals interested in conducting consumer neuroscience research in the field of advertising.

Hence, the findings of this article offer advertising researchers and professionals an accurate and objective framework of the main current scientific research combining neuroimaging and advertising. Advertising managers as well as information and documentation professionals, by incorporating these findings into their strategies, would bolster and guarantee their credibility, persuasion, and value in a time marked by an unprecedented explosion in information.

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References

1. Batra, R.; Ramaswamy, V.; Alden, D.L.; Steenkamp, J.-B.E.; Ramachander, S. Effects of Brand Local and Nonlocal Origin on Consumer Attitudes in Developing Countries. *J. Consum. Psychol.* **2000**, *9*, 83–95. [CrossRef]
2. Carrington, M.J.; Neville, B.A.; Whitwell, G.J. Lost in Translation: Exploring the Ethical Consumer Intention–Behavior Gap. *J. Bus. Res.* **2014**, *67*, 2759–2767. [CrossRef]
3. Plassmann, H.; Ramsøy, T.Z.; Milosavljevic, M. Branding the Brain: A Critical Review and Outlook. *J. Consum. Psychol.* **2012**, *22*, 18–36. [CrossRef]
4. Venkatraman, V.; Clithero, J.A.; Fitzsimons, G.J.; Huettel, S.A. New Scanner Data for Brand Marketers: How Neuroscience Can Help Better Understand Differences in Brand Preferences. *J. Consum. Psychol.* **2012**, *22*, 143–153. [CrossRef]
5. Khushaba, R.N.; Wise, C.; Kodagoda, S.; Louviere, J.; Kahn, B.E.; Townsend, C. Consumer Neuroscience: Assessing the Brain Response to Marketing Stimuli Using Electroencephalogram (EEG) and Eye Tracking. *Expert Syst. Appl.* **2013**, *40*, 3803–3812. [CrossRef]
6. Casado-Aranda, L.-A.; Sánchez-Fernández, J.; Montoro-Ríos, F.J. How Consumers Process Online Privacy, Financial, and Performance Risks: An FMRI Study. *Cyber Psychol. Behav. Soc. Netw.* **2018**, *21*, 556–562. [CrossRef] [PubMed]
7. Hubert, M.; Kenning, P. A Current Overview of Consumer Neuroscience. *J. Consum. Behav.* **2008**, *7*, 272–292. [CrossRef]
8. Golnar-Nik, P.; Farashi, S.; Safari, M.-S. The Application of EEG Power for the Prediction and Interpretation of Consumer Decision-Making: A Neuromarketing Study. *Physiol. Behav.* **2019**, *207*, 90–98. [CrossRef]
9. Lee, N.; Chamberlain, L.; Brandes, L. Welcome to the Jungle! The Neuromarketing Literature through the Eyes of a Newcomer. *Eur. J. Mark.* **2018**, *52*, 4–38. [CrossRef]
10. Daugherty, T.; Hoffman, E.; Kennedy, K. Research in Reverse: Ad Testing Using an Inductive Consumer Neuroscience Approach. *J. Bus. Res.* **2016**, *69*, 3168–3176. [CrossRef]
11. Falk, E.B.; Berkman, E.T.; Mann, T.; Harrison, B.; Lieberman, M.D. Predicting Persuasion-Induced Behavior Change from the Brain. *J. Neurosci.* **2010**, *30*, 8421–8424. [CrossRef] [PubMed]

12. Casado-Aranda, L.-A.; der Laan, L.N.V.; Sánchez-Fernández, J. Neural Correlates of Gender Congruence in Audiovisual Commercials for Gender-Targeted Products: An FMRI Study. *Hum. Brain Mapp.* **2018**, *39*, 4360–4372. [CrossRef] [PubMed]
13. Dimoka, A.; Banker, R.D.; Benbasat, I.; Davis, F.D.; Dennis, A.R.; Gefen, D.; Gupta, A.; Ischebeck, A.; Kenning, P.; Pavlou, P.A.; et al. On the Use of Neurophysiological Tools in IS Research: Developing a Research Agenda for NeuroIS. *MIS Q.* **2010**, *36*, 3. [CrossRef]
14. Casado-Aranda, L.-A.; Dimoka, A.; Sánchez-Fernández, J. Consumer Processing of Online Trust Signals: A Neuroimaging Study. *J. Interact. Mark.* **2019**, *47*, 159–180. [CrossRef]
15. Martínez-Fiestas, M.; del Jesus, M.I.V.; Sánchez-Fernández, J.; Montoro-Rios, F.J. A Psychophysiological Approach For Measuring Response to Messaging: How Consumers Emotionally Process Green Advertising. *J. Advert. Res.* **2015**, *55*, 192–205. [CrossRef]
16. Adil, S.; Lacoste-Badie, S.; Droulers, O. Face Presence and Gaze Direction In Print Advertisements: How They Influence Consumer Responses: An Eye-Tracking Study. *J. Advert. Res.* **2018**, *58*, 443–455. [CrossRef]
17. Belch, G.E. An Examination of Comparative and Noncomparative Television Commercials: The Effects of Claim Variation and Repetition on Cognitive Response and Message Acceptance. *J. Mark. Res. (JMR)* **1981**, *18*, 333–349. [CrossRef]
18. Kruikemeier, S.; Lecheler, S.; Boyer, M.M. Learning from News on Different Media Platforms: An Eye-Tracking Experiment. *Political Commun.* **2018**, *35*, 75–96. [CrossRef]
19. Russell, C.A.; Swasy, J.L.; Russell, D.W.; Engel, L. Eye-Tracking Evidence That Happy Faces Impair Verbal Message Comprehension: The Case of Health Warnings in Direct-to-Consumer Pharmaceutical Television Commercials. *Int. J. Advert.* **2017**, *36*, 82–106. [CrossRef]
20. Harris, J.M.; Ciorciari, J.; Gountas, J. Consumer Neuroscience for Marketing Researchers. *J. Consum. Behav.* **2018**. [CrossRef]
21. Casado-Aranda, L.-A.; Sánchez-Fernández, J.; Montoro-Ríos, F.J. Looking at the Brain: How Consumers Process Advertising. *Role Lang. Symb. Promot. Strateg. Mark. Schemes* **2019**, 85–105. [CrossRef]
22. Schmälzle, R.; Häcker, F.E.K.; Honey, C.J.; Hasson, U. Engaged Listeners: Shared Neural Processing of Powerful Political Speeches. *Soc. Cogn. Affect. Neurosci.* **2015**, *10*, 1137–1143. [CrossRef] [PubMed]
23. Weber, R.; Mangus, J.M.; Huskey, R. Brain Imaging in Communication Research: A Practical Guide to Understanding and Evaluating FMRI Studies. *Commun. Methods Meas.* **2015**, *9*, 5–29. [CrossRef]
24. Solnais, C.; Andreu-Perez, J.; Sánchez-Fernández, J.; Andréu-Abela, J. The Contribution of Neuroscience to Consumer Research: A Conceptual Framework and Empirical Review. *J. Econ. Psychol.* **2013**, *36*, 68–81. [CrossRef]
25. Krampe, C.; Strelow, E.; Haas, A.; Kenning, P. The Application of Mobile FNIRS to "Shopper Neuroscience"—First Insights from a Merchandising Communication Study. *Eur. J. Mark.* **2018**, *52*, 244–259. [CrossRef]
26. Rothschild, M.L.; Thorson, E.; Reeves, B.; Hirsch, J.E.; Goldstein, R. Eeg Activity and the Processing of Television Commercials. *Commun. Res.* **1986**, *13*, 182–220. [CrossRef]
27. Langleben, D.D.; Loughead, J.W.; Ruparel, K.; Hakun, J.G.; Busch-Winokur, S.; Holloway, M.B.; Strasser, A.A.; Cappella, J.N.; Lerman, C. Reduced Prefrontal and Temporal Processing and Recall of High "Sensation Value" Ads. *NeuroImage* **2009**, *46*, 219–225. [CrossRef]
28. Stoll, M.; Baecke, S.; Kenning, P. What They See Is What They Get? An FMRI-Study on Neural Correlates of Attractive Packaging. *J. Consum. Behav.* **2008**, *7*, 342–359. [CrossRef]
29. Falk, E.B.; Berkman, E.T.; Whalen, D.; Lieberman, M.D. Neural Activity during Health Messaging Predicts Reductions in Smoking above and beyond Self-Report. *Health Psychol.* **2011**, *30*, 177–185. [CrossRef]
30. Casado-Aranda, L.-A.; Sánchez-Fernández, J.; Montoro-Ríos, F.J. Neural Correlates of Voice Gender and Message Framing in Advertising: A Functional MRI Study. *J. Neurosci. Psychol. Econ.* **2017**, *10*, 121–136. [CrossRef]
31. Chang, H.J.J.; O'Boyle, M.; Anderson, R.C.; Suttikun, C. An FMRI Study of Advertising Appeals and Their Relationship to Product Attractiveness and Buying Intentions: An FMRI Study of Advertising Appeals. *J. Consum. Behav.* **2016**. [CrossRef]
32. Cobo, M.J.; López-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. An Approach for Detecting, Quantifying, and Visualizing the Evolution of a Research Field: A Practical Application to the Fuzzy Sets Theory Field. *J. Informetr.* **2011**, *5*, 146–166. [CrossRef]
33. Cobo, M.J.; López-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. SciMAT: A New Science Mapping Analysis Software Tool. *J. Am. Soc. Inf. Sci. Technol.* **2012**, *63*, 1609–1630. [CrossRef]
34. Morris, J.D.; Klahr, N.J.; Shen, F.; Villegas, J.; Wright, P.; He, G.; Liu, Y. Mapping a Multidimensional Emotion in Response to Television Commercials. *Hum. Brain Mapp.* **2009**, *30*, 789–796. [CrossRef] [PubMed]
35. Feng, S.; Morris, J.D. Decoding Neural Responses to Emotion in Television Commercials. *J. Advert. Res.* **2016**, *56*. [CrossRef]
36. Vecchiato, G.; Cherubino, P.; Maglione, A.G.; Ezquierro, M.T.H.; Marinozzi, F.; Bini, F.; Trettel, A.; Babiloni, F. How to Measure Cerebral Correlates of Emotions in Marketing Relevant Tasks. *Cogn. Comput.* **2014**, *6*, 856–871. [CrossRef]
37. Cheung, M.-C.; Law, D.; Yip, J.; Wong, C.W.Y. Emotional Responses to Visual Art and Commercial Stimuli: Implications for Creativity and Aesthetics. *Front. Psychol.* **2019**, *10*. [CrossRef]
38. Han, C.-H.; Lee, J.-H.; Lim, J.-H.; Kim, Y.-W.; Im, C.-H. Global Electroencephalography Synchronization as a New Indicator for Tracking Emotional Changes of a Group of Individuals during Video Watching. *Front. Hum. Neurosci.* **2017**, *11*. [CrossRef]
39. Burns, S.M.; Barnes, L.N.; McCulloh, I.A.; Dagher, M.M.; Falk, E.B.; Storey, J.D.; Lieberman, M.D. Making Social Neuroscience Less WEIRD: Using FNIRS to Measure Neural Signatures of Persuasive Influence in a Middle East Participant Sample. *J. Pers. Soc. Psychol.* **2019**, *116*, e1–e11. [CrossRef]

40. Smith, M.E.; Gevins, A. Attention and Brain Activity While Watching Television: Components of Viewer Engagement. *Media Psychol.* **2004**, *6*, 285–305. [CrossRef]
41. Shestyuk, A.Y.; Kasinathan, K.; Karapoondinott, V.; Knight, R.T.; Gurumoorthy, R. Individual EEG Measures of Attention, Memory, and Motivation Predict Population Level TV Viewership and Twitter Engagement. *PLoS ONE* **2019**, *14*, e0214507. [CrossRef]
42. Rossiter, J.R.; Silberstein, R.B.; Harris, P.G.; Nield, G. Brain-Imaging Detection of Visual Scene Encoding in Long-Term Memory for TV Commercials. *J. Advert. Res.* **2001**, *41*, 13–21. [CrossRef]
43. De Vico Fallani, F.; Astolfi, L.; Cincotti, F.; Mattia, D.; Marciani, M.G.; Gao, S.; Salinari, S.; Soranzo, R.; Colosimo, A.; Babiloni, F. Structure of the Cortical Networks during Successful Memory Encoding in TV Commercials. *Clin. Neurophysiol.* **2008**, *119*, 2231–2237. [CrossRef] [PubMed]
44. Astolfi, L.; Fallani, F.D.V.; Cincotti, F.; Mattia, D.; Bianchi, L.; Marciani, M.G.; Salinari, S.; Gaudiano, I.; Scarano, G.; Soranzo, R.; et al. Brain Activity during the Memorization of Visual Scenes from TV Commercials: An Application of High Resolution EEG and Steady State Somatosensory Evoked Potentials Technologies. *J. Physiol. Paris* **2009**, *103*, 333–341. [CrossRef]
45. Morey, A.C. Memory for Positive and Negative Political TV Ads: The Role of Partisanship and Gamma Power. *Political Commun.* **2017**, *34*, 404–423. [CrossRef]
46. Bakalash, T.; Riemer, H. Exploring Ad-Elicited Emotional Arousal and Memory for the Ad Using FMRI. *J. Advert.* **2013**, *42*, 275–291. [CrossRef]
47. Seelig, D.; Wang, A.-L.; Jaganathan, K.; Loughead, J.W.; Blady, S.J.; Childress, A.R.; Romer, D.; Langleben, D.D. Low Message Sensation Health Promotion Videos Are Better Remembered and Activate Areas of the Brain Associated with Memory Encoding. *PLoS ONE* **2014**, *9*, e113256. [CrossRef]
48. Doré, B.P.; Tompson, S.H.; O'Donnell, M.B.; An, L.C.; Strecher, V.; Falk, E.B. Neural Mechanisms of Emotion Regulation Moderate the Predictive Value of Affective and Value-Related Brain Responses to Persuasive Messages. *J. Neurosci.* **2019**, *39*, 1293–1300. [CrossRef]
49. Burns, S.M.; Barnes, L.N.; Katzman, P.L.; Ames, D.L.; Falk, E.B.; Lieberman, M.D. A Functional near Infrared Spectroscopy (FNIRS) Replication of the Sunscreen Persuasion Paradigm. *Soc. Cogn. Affect. Neurosci.* **2018**, *13*, 628–636. [CrossRef]
50. Courtney, A.L.; Rapuano, K.M.; Sargent, J.D.; Heatherton, T.F.; Kelley, W.M. Reward System Activation in Response to Alcohol Advertisements Predicts College Drinking. *J. Stud. Alcohol Drugs* **2018**, *79*, 29–38. [CrossRef]
51. Chan, H.-Y.; Smidts, A.; Schoots, V.C.; Dietvorst, R.C.; Boksem, M.A.S. Neural Similarity at Temporal Lobe and Cerebellum Predicts Out-of-Sample Preference and Recall for Video Stimuli. *Neuroimage* **2019**, *197*, 391–401. [CrossRef] [PubMed]
52. Cascio, C.N.; Scholz, C.; Falk, E.B. Social Influence and the Brain: Persuasion, Susceptibility to Influence and Retransmission. *Curr. Opin. Behav. Sci.* **2015**, *3*, 51–57. [CrossRef]
53. Kuss, K.; Falk, A.; Trautner, P.; Montag, C.; Weber, B.; Fliessbach, K. Neuronal Correlates of Social Decision Making Are Influenced by Social Value Orientation—An FMRI Study. *Front. Behav. Neurosci.* **2015**, *9*. [CrossRef] [PubMed]
54. Guixeres, J.; Bigné, E.; Ausín Azofra, J.M.; Alcañiz Raya, M.; Colomer Granero, A.; Fuentes Hurtado, F.; Naranjo Ornedo, V. Consumer Neuroscience-Based Metrics Predict Recall, Liking and Viewing Rates in Online Advertising. *Front. Psychol.* **2017**, *8*. [CrossRef]
55. Boksem, M.A.S.; Smidts, A. Brain Responses to Movie Trailers Predict Individual Preferences for Movies and Their Population-Wide Commercial Success. *J. Mark. Res. (JMR)* **2015**, *52*, 482–492. [CrossRef]
56. Deitz, G.D.; Royne, M.B.; Peasley, M.C.; Huang, J.C.; Coleman, J.T. EEG-Based Measures versus Panel Ratings: Predicting Social Media-Based Behavioral Response to Super Bowl Ads. *J. Advert. Res.* **2016**, *56*, 217–227. [CrossRef]
57. Casado-Aranda, L.-A.; Martínez-Fiestas, M.; Sánchez-Fernández, J. Neural Effects of Environmental Advertising: An FMRI Analysis of Voice Age and Temporal Framing. *J. Environ. Manag.* **2018**, *206*, 664–675. [CrossRef]
58. Vezich, I.S.; Gunter, B.C.; Lieberman, M.D. The Mere Green Effect: An FMRI Study of pro-Environmental Advertisements. *Soc. Neurosci.* **2017**, *12*, 400–408. [CrossRef]
59. Medina, C.A.G.; Martinez-Fiestas, M.; Viedma-del-Jesús, M.I.; Casado Aranda, L.A. The Processing of Price during Purchase Decision Making: Are There Neural Differences among Prosocial and Non-Prosocial Consumers? *J. Clean. Prod.* **2020**, *271*, 122648. [CrossRef]
60. Lee, E.-J.; Choi, H.; Han, J.; Kim, D.H.; Ko, E.; Kim, K.H. How to "Nudge" Your Consumers toward Sustainable Fashion Consumption: An FMRI Investigation. *J. Bus. Res.* **2020**. [CrossRef]
61. Couwenberg, L.E.; Boksem, M.A.S.; Dietvorst, R.C.; Worm, L.; Verbeke, W.J.M.I.; Smidts, A. Neural Responses to Functional and Experiential Ad Appeals: Explaining Ad Effectiveness. *Int. J. Res. Mark.* **2017**, *34*, 355–366. [CrossRef]
62. Chua, H.F.; Liberzon, I.; Welsh, R.C.; Strecher, V.J. Neural Correlates of Message Tailoring and Self-Relatedness in Smoking Cessation Programming. *Biol. Psychiatry* **2009**, *65*, 165–168. [CrossRef]
63. Spezio, M.L.; Rangel, A.; Alvarez, R.M.; O'Doherty, J.P.; Mattes, K.; Todorov, A.; Kim, H.; Adolphs, R. A Neural Basis for the Effect of Candidate Appearance on Election Outcomes. *Soc. Cogn. Affect. Neurosci.* **2008**, *3*, 344–352. [CrossRef] [PubMed]
64. Casado-Aranda, L.-A.; Venkatraman, V.; Sánchez-Fernández, J.; Luque-Martínez, T. Does Partisan Bias Modulate Neural Processing of Political Information? An Analysis of the Neural Correlates of Corruption and Positive Messages. *Political Psychol.* **2019**. [CrossRef]

65. Zamboni, G.; Gozzi, M.; Krueger, F.; Duhamel, J.-R.; Sirigu, A.; Grafman, J. Individualism, Conservatism, and Radicalism as Criteria for Processing Political Beliefs: A Parametric FMRI Study. *Soc. Neurosci.* **2009**, *4*, 367–383. [CrossRef] [PubMed]
66. Casado-Aranda, L.-A.; Sánchez-Fernández, J.; Luque-Martínez, T. Modulating the Neural Bases of Political Communications: Political Involvement and Perception of the Economic Situation. *Political Behav.* **2020**. [CrossRef]
67. Jordão, I.L.D.S.; Souza, M.T.D.; Oliveira, J.H.C.D.; Giraldi, J.D.M.E. Neuromarketing Applied to Consumer Behaviour: An Integrative Literature Review between 2010 and 2015. *Int. J. Bus. Forecast. Mark. Intell.* **2017**, *3*, 270–288. [CrossRef]
68. Ariely, D.; Berns, G.S. Neuromarketing: The Hope and Hype of Neuroimaging in Business. *Nat. Rev. Neurosci.* **2010**, *11*, 284–292. [CrossRef]
69. Ramsøy, T.Z. Building a Foundation for Neuromarketing And Consumer Neuroscience Research: How Researchers Can Apply Academic Rigor To the Neuroscientific Study of Advertising Effects. *J. Advert. Res.* **2019**, *59*, 281–294. [CrossRef]
70. Reimann, M.; Schilke, O.; Weber, B.; Neuhaus, C.; Zaichkowsky, J. Functional Magnetic Resonance Imaging in Consumer Research: A Review and Application. *Psychol. Mark.* **2011**, *28*, 608–637. [CrossRef]
71. Weber, B. Consumer Neuroscience and Neuromarketing. In *Neuroeconomics (Studies in Neuroscience, Psychology and Behavioral Economics)*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 333–341. ISBN 978-3-642-35922-4.
72. Everett, J.A.; Colombatto, C.; Chituc, V.; Brady, W.J.; Crockett, M. The Effectiveness of Moral Messages on Public Health Behavioral Intentions during the COVID-19 Pandemic. *PsyArXiv Prepr.* **2020**. [CrossRef]
73. Baek, T.H.; Yoon, S.; Kim, S. When Environmental Messages Should Be Assertive: Examining the Moderating Role of Effort Investment. *Int. J. Advert.* **2015**, *34*, 135–157. [CrossRef]