# Converging Technologies in Neuromarketing: Analysis of Trends and Ethics

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**ABSTRACT:**

The convergence of neuroscience, technology, and marketing has given rise to neuromarketing, a field that leverages advanced neuroimaging techniques and artificial intelligence to analyze consumer behavior. The study aims to investigate the development, the uses, and the ethical problems of converging technologies in neuromarketing, emphasizing the tension between scientific progress and the regulatory frame. The trends were developed through a bibliometric analysis of Scopus-indexed literature for 2015-2024, focusing on keyword clustering, co-occurrence networks, and geographical distribution mapping. Five major thematic clusters were discovered as follows: (1) applications in neuromarketing, (2) neuroscientific methods, (3) data analytics and predictive modeling, (4) ethical and regulatory challenges, and (5) theoretical foundations. The United States leads scientific production, while Europe and emergent economies are behind, confirming that a global interest is aroused by the technological progress made by neuromarketing. Such that, machine learning-enabled Electroencephalograph (EEG) and Artificial Intelligence (AI) horizons have conferred on us advanced capacities for prediction; however, grave concerns over consumer privacy, manipulation, and ethical accountability exist in the ether still. The study highlights the need for concerted interactions across fields to ensure that regulatory frameworks come to the fore that assimilate some balance between technological development and ethical integrity for future neuromarketing requirements in a much more responsible manner.

*Keywords: Artificial intelligence, bibliometric analysis, consumer behavior, emerging technologies, marketing innovation, neuromarketing.*

## 1. Introduction

Neurotechnologies evolve with the speed of lightning and present the most challenging issue in ethics, human rights, and privacy. These advancements in technology raise some pivotal concerns that relate to human dignity and the likely infringing of basic rights, particularly in regard to mental privacy (Sieber, 2019). Its increased capability in decoding neural signals and predicting mental states poses very serious risks to people's cognitive autonomy, suggesting that new human rights should be established to ensure mental privacy and the wellbeing of their thought processes (Ienca & Andorno, 2017a). In light of this, it becomes a necessity to analyze the different consequences brought about

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by neurotechnologies and institute conducive guiding frameworks for regulating their proliferation.

In accordance with the above, authors such as Yuste et al. (2017) state that, for the protection of neural data, cognitive freedom and the restoration of human rights, governments must act under some ethical priorities in terms of legislation such as mental privacy, personal identity, equitable access, which requires regulatory interventions that must be done with great care, to which Eyre et al. (2020) raise the reflection that these regulatory maneuvers may represent a barrier to innovation and entrepreneurship in neuroscience; therefore, a promising solution would be to exercise multi-stakeholder governance models and adaptive regulatory schemes, which allow the evolution and progress of technologies for neuroscience, along with the protection of human rights (Liv & Greenbaum, 2024); The way to go, then, is not to take binary positions between security (human rights) and freedom (innovation), but to establish an interdisciplinary and dialogical legal design (Brown, 2024).

In that ethical perspective, it is in the development of persuasive techniques and brain-machine interfaces that specific guiding principles will be needed to minimize risks while maximizing benefits. In this sense, Spahn (2012) considers that neurocognitive technologies must be evaluated in the light of ethical principles derived from discourse ethics, in order to ensure their responsible implementation. However, further research is still needed to establish a comprehensive ethical framework that contemplates both the individual and collective implications of these innovations (Fiske et al., 2019). The lack of clear regulations in this area could create a legal and ethical vacuum that favors the misuse of these technologies in areas such as advertising, neuromarketing and cognitive surveillance.

The applications of neurotechnologies can generate significant societal benefits, especially in the field of neurorehabilitation and augmented communication; in this order, the study of (W. Cho et al., 2023) focuses on Biohybrid strategies, such as integrating electrodes into brain infrastructure, have shown promise for chronic neurochemical detection and decoding of neural signals; however, these technologies also present challenges in terms of biocompatibility, as the implementation of brain-machine interfaces must ensure long-term safety and minimize the risks of rejection or neuronal damage (Pisarchik et al., 2019). The convergence between neuroimaging, psychotropic drugs, and neural interfaces raises new ethical questions at the intersection of technology and applied neuroscience (Wolpe, 2002).

Given the growing impact of neurotechnologies in various sectors, it is crucial to address the ethical and legal concerns associated with their development and application. There has been a raise in debates -around neuromarketing and other forms of cognitive operation- regarding the responsibility of the actors involved and safeguards that need to be taken to protect clients from invasive practices (Wolpe, 2002). Despite the positive potential of AI, in mental health, Fiske et al. (2019) argue that care must be developed in considering the social and ethical implications of its application so as to avoid possible abuses. Within that context, continued research in this field and the establishment of public regulating policies for a reasonable and accountable practice of neurotechnologies persist unavoidable.

## 2.  Converging Technologies applied to Neuromarketing

Converging technologies in neuromarketing employ various neuroimaging techniques, such as Electroencephalograph (EEG), to better understand consumer behavior and preferences. According to Georgiadis et al. (2022) EEG is gaining popularity because it is cheaper and also a non-invasive alternative, making it possible to analyze brainwave patterns that are correlated to consumer attitudes and decisions. In other hand, it has reported successful use of ML to anticipate customer preferences with Frontal Alpha Asymmetry (FAA), as well as the Late Positive Potential (LPP), both techniques as a reliable predictor of emotional responses to advertising stimuli (Byrne et al., 2022). Besides that, new classification approaches such as sparse representation classification have improved precision in recognizing cognitive and affective states during exposure to marketing stimuli (Oikonomou et al., 2023). Moreover, Artificial Neural Networks (ANN) delivers robust alternative methods for consumer behavior analysis, being more cost-effective than the typical neuromarketing gears (Ahmed et al., 2022). Following the idea of Lyreskog et al. (2023), Converging technologies such as these would transformation marketing strategies and also expand their predictive capabilities in understanding customer choices.

Certainly, classification technologies such as Sparse Representation (SRC) have shown a promising outlook for emotional prediction based on neurological data, criticisms arise of the validity of such models; for M. Li et al. (2023), sophisticated approaches such as EEG graphs require very diverse training and highly rigorous validation methodologies, in order to try to reduce bias in the results. On the other hand, researches that uses highly homogeneous data such as age, cultural origin, sex/gender, can reduce and limit the predictive capacity of the model that is intended to be applied to broader, real, and diverse contexts (R. Li et al., 2024). Alarcao & Fonseca (2019) show in their study, that many emotional classification models exhibit high accuracy under controlled laboratory conditions, but have erratic behaviors in the face of uncontrolled populations or stimuli not trained in such laboratory tests; These reflections invite us to consider as a critical point, the incorporation of equity metrics, evaluating heterogeneous datasets, in order to raise scientific solidity, hand in hand with the ethical use of artificial intelligence in neuromarketing processes.

### 2.1. Relevant Technologies for the future of Neuromarketing

The future promises neuromarketing a great set of advanced technologies to work with: functional Near-Infrared Spectroscopy (fNIRS), neurofeedback, Virtual/Augmented Reality (VR/AR), and Artificial Intelligence (AI) with Machine Learning (ML). fNIRS is a non-invasive way of providing real-time insights about how consumers respond to a specific campaign (Khodatars et al., 2021). Neurofeedback allows consumers to self-regulate their brain activity and thus may engage them more and allow better decisions to be made (Mehler et al., 2019). The merging of VR/AR creates immersive scenes that elicit the emotional responses further influencing consumer behavior (Y. Cho et al., 2021). AI and ML can analyze large datasets for the behavioral trends of consumers, optimizing marketing strategies by Minimum Redundancy Maximum Relevance (MRMR) and other such advanced feature selection procedures that can improve the predictive accuracy of

the models while giving better interpretability (Macpherson et al., 2021; Zhao et al., 2019). Together, such technologies become the new ways marketers gain insight into the mind of the consumer and how best to influence it, which leads to modifying the concept of personalized and effective marketing strategies.

According to Cherubino et al. (2019), while neurofeedback increases consumer engagement by allowing individuals to control the brain activity in real-time, these same authors state that VR and AR technologies deliver immersive settings that reproduce real-life shopping experiences and, thus, permit sensitive emotional responses and decision-making processes. AI and ML techniques, including Support Vector Machines and Artificial Neural Networks, are also growing in acceptance to study multifaceted data sets stemming from EEG signals, which furthers the equipment for predicting consumers' preferences and behaviors (Mashrur et al., 2022). These technologies, acting in continuum, would hence pave an even more enhanced ground for neuromarketing strategies, making them more efficient and sensitive to the consumer's needs (Kovaleva, 2023).

The application of artificial intelligence (AI), virtual reality (VR), and the Internet of Things (IoT) into neuromarketing is renovating the ground of customer behavior study and understanding. AI extends neuromarketing by modeling consumer preference and then extracting neurological data by reading subconscious reactions triggered by marketing stimuli, leading to personalized and ultimately more emotionally engaging marketing approaches (Anupama & Rosita, 2024). Researchers can now investigate how consumers interact with products in a controlled environment with applications in virtual reality, such as virtual supermarket environments, where all normal challenges of testing in real-life scenarios are avoided (Quevedo et al., 2018). IoT infrastructure facilitates collection of real-time data on consumer response, providing instantaneous biofeedback and therefore deeper insights into decision-making processes (Vasiljević et al., 2019). These together would enhance the accuracy of consumer behavior analysis and present ethical concerns around data privacy and algorithmic bias, which a responsible marketing practice must attend to (Anupama & Rosita, 2024; Fahim et al., 2024).

In addition to the above, although technologies such as VR, AI, IoT have improved techniques in neuromarketing on how to analyze consumer behaviors, serious ethical concerns have also been raised about consumer privacy, regarding algorithmic biases as well as data privacy. For Goncalves et al. (2024), the use of AI in neuromarketing could compromise consumer privacy, specifically in the processes of collection and analysis of neurophysiological data collected without full informed consent; in this sense, García et al. (2025) proposes "Data Hazards", which consists of an ethical tool to identify risks related to projects for the use of data in neuroscience, highlighting the requirement for shared ethical reflections to mitigate such risks.

On the other hand, and focusing on VR technology, Raja & Al-Baghli (2025) states that there is sensitive data in biometric data collection processes such as emotional responses and brain activity, which could be used in neuromarketing studies without the user's consent or knowledge, which triggers ethical alarms; that is why it is necessary to establish clear policies on the storage, use, and distribution of neurophysiological data in neuromarketing processes (Ienca et al., 2022), implementing sophisticated informed consent mechanisms; for Ye et al. (2021), models of emotional recognition that are

representative and equitable should be developed, reducing the possibilities of bias in research, protecting ethical and transparent marketing practices.

Information And Communication Technologies (ICT) and neurology together have gained a great deal of knowledge on the mechanisms underlying consumer decision-making (Giansanti, 2023). The accuracy of emotion prediction in neuromarketing applications is significantly increased by other innovative EEG signal preprocessing and classification methods, such as hybrid fuzzy classification algorithms (Shah et al., 2022), these emerging technologies has become a component defining the face of the neuromarketing scene anew, tightfitting deep insights into customer behavior.

In neuromarketing, emerging technologies, including AI, VR and Brain-Computer Interfaces (BCIs), are being useful in an ever-growing way to offer better understandings and involvement of customers. According to Brookes et al. (2020), the Unity Experiment Framework (UXF) lets researchers to generate an immersive VR environment capable of simulating consumer experiences and tracking behavioral responses to add another layer to old-style methods of marketing research. Additionally, tools based on AI and ML are now becoming widely employed for neural data analyses, such as predicting consumer preferences and how decisions are made based on brain activity (Livezey et al., 2019; Singh et al., 2021). BCIs, especially Steady-State Visually Evoked Potentials (SSVEP), can categorize shopper responses toward marketing stimuli with high exactness to give understanding about the level of engagement of consumers during advertisements (Guney et al., 2022). Together, these technologies allow marketers to understand consumers better so they may implement resonance strategies for target audiences while incorporating ethical issues on data privacy and user agency (Goering et al., 2021).

## 2.2. Ethics in the world of using converging technologies for neuromarketing

Substantial ethical issues come into the spotlight in order to assure the just standards used in neuromarketing due to the convergence of technologies in this new field of practice. Certainly, combining neuroscience, psychology, and marketing within neuromarketing opens the veil to the consumers' mind on a sub-aware level, but this very sophistication also comes along with some ethical dilemmas concerning informed consent, privacy, and possible manipulation driving consumer decisions similar to what was discussed in the previous sections (Akaeva & Hametova, 2024; Sindhuja & Malik, 2024). Techniques such as Functional Magnetic Resconance Imaging (fMRI) and facial coding might be seen as effective in evaluating cognitive processing, though they may encroach upon personal privacy so much as to engender discrimination or coerce behavior (Lyu & Mañas-Viniegra, 2021); moreover, the report of neurodata with AI analysis suggests risks of biasedness and unethical abuse (Anupama & Rosita, 2024). Thus, it is important that researchers and companies adhere to ethical perspectives to create transparency, beneficence, and protection of fragile populations with the purpose of building faith and credibility of neuromarketing practices (Akaeva & Hametova, 2024; Vuković, 2023).

The intertwine of these technologies within neuromarketing raises serious ethical issues that need to be dealt with. Neuromarketing lifts the parameters of advanced neuroscience for studying consumer behavior. Therefore, following the idea of Mohd Isa et al. (2019), aspects such as informed consent and confidentiality, as well as the possibility of manipulation, become some of the larger dilemmas of ethics. Furthermore, the absence

of regulatory outlines regarding neurotechnology practices only makes these worries even more disturbing, highlighting the requirement of rules that can distinguish between "neuro data" and "personal data" so as to secure individual privacy (M. Skriabin et al., 2021).

Regulatory inconsistencies regarding neuromarketing further weaken the standardization and unison of ethical practice regarding the protection of consumers under the massive risks of protection. Neuromarketing processes like analyzing brain and biometric data, has gone beyond adequate bounds of existing laws that allegedly safeguard the privacy and informed consent of individuals (Stanton et al., 2017); In this hand, for example, the EU has adopted General Data Protection Regulation (GDPR) for the rights of its citizens, while other jurisdictions may not have such laws (Fisher et al., 2010); this is causing problems and tensions among legislations and neuromarketing practices, according to Murphy et al. (2008), regulatory inconsistencies results in relatively free collection and use of personal data, which some people argue to be an invasion of privacy. This gap in regulation makes it possible for firms to outsource their operations into jurisdictions with weaker regulations, thus avoiding the stricter ethical standards. The international lack of regulations consensus on defining and treating neurophysiological data makes developing coherent and effective policies all the more difficult (Ienca & Andorno, 2017b) . To attend those conflicts, Zuboff (2019) stated that voluntary codes of ethics have been proposed by organizations, such as the Neuromarketing Science & Business Association (NMSBA), but adoption and enforcement vary drastically, therefore limiting their effectiveness in protecting consumer rights. It is, therefore, necessary to create an international legal framework to harmonize existing regulations, therefore establishing minimum mandatory standards for the practice of neuromarketing and ensuring that all jurisdictions protect the autonomy and privacy of individuals.

## 3. Methodology

The methodology of the present study is oriented towards the literature review indexed in the Scopus database. To do this, the search equation (Technology + Neuromarketing + Ethics) was used, with a time frame of 10 years (2015-2024). The strategy adopted has assisted in identifying relevant publications in neuromarketing and their analogy to technological advancements and related ethical issues. The data collection would occur on the basis of metadata of the publications including title, authors, year of publication, country of affiliation, areas of knowledge, and type of document, thus providing an intensive and up-to-date analysis of academic production in the field.

Subsequently, the results obtained were processed and analyzed using bibliometric techniques. The VOSviewer software was used to perform a clustering analysis, which allowed identifying patterns in scientific production and establishing co-occurrence networks between key terms. In addition, trends in the geographical distribution of publications, the main areas of knowledge involved, and the evolution of the number of documents published per year were examined. This methodological approach not only provides a structured view of the state of the art at the intersection between technology, neuromarketing, and ethics, but also facilitates the identification of research gaps and future opportunities in the field.

## 4. Results: Bibliographic Analysis

The analysis of the clusters, using VOSviewer software, reveals five clusters (see **Figure 1**); Cluster 1 is the most interconnected and frequently occurring, with the highest total links and occurrences weight, while Cluster 2 stands out for having the highest average citations, indicating its items are highly influential. Cluster 3 and Cluster 4 are less interconnected and less frequently occurring, with lower total links and occurrences weight; and finally, Cluster 5 has a moderate number of items but lower average citations, suggesting it is less influential in terms of citations. Overall, the clusters vary significantly in their connectivity, frequency, and citation impact.
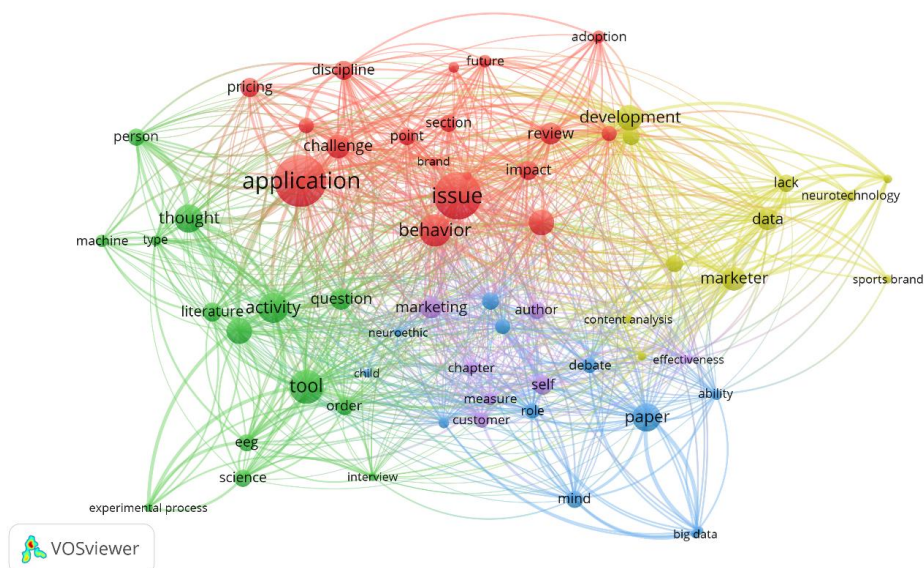


*Figure 1. Clusters based on equation (Technology + Neuromarketing + Ethics), 2015 – 2024 in Scopus. Source: Own elaboration, based on results in Scopus.*

According to the clusters (See **Table 1**) obtained in this study, there is a complexity and evolution of neuromarketing in its intersection with technology and ethics, evidencing tensions between scientific progress and its regulatory and social implications. Thematic segmentation suggests that the field is not only developed from an applied perspective—with a focus on the impact on consumer behavior—but also from a methodological dimension, where the use of tools such as EEG and Big Data is positioned as a central axis in the generation of knowledge. However, the existence of a specific cluster on regulation and ethics highlights that, despite technological advances, regulatory gaps and concerns about the legitimacy of the use of neuroscience in the commercial field persist. In addition, the presence of a theoretical cluster suggests that neuromarketing is still in a process of disciplinary consolidation, in which not only its applications are

debated, but also its role within science and its conceptual delimitation. These clusters results reveal that the expansion of neuromarketing is not homogeneous, but is conditioned by methodological, regulatory and epistemological factors, which raises the need for an interdisciplinary dialogue that guarantees its ethical and sustainable development.

**Table 1** Clusters and themes (Technology + Neuromarketing + Ethics)

| Cluster | Cluster Topic | Main keywords | Cluster Description |
|---|---|---|---|
| 1 | Red- Applications of neuromarketing | application, behavior, challenge, ethical concern, issue, impact | It explores the use of neuromarketing in different contexts, including ethical challenges and its impact on consumer behavior. |
| 2 | Green - Methods and tools in neuroscience | tool, EEG, science, experimental process, literature | It addresses the methods and tools used in neuroscience studies applied to marketing, including EEG and other devices. |
| 3 | Blue - Data and predictive models | data, big data, ability, paper, mind | It examines the use of big data and predictive models to improve neuroscience-based marketing strategies. |
| 4 | Yellow - Regulation and ethics in neurotechnology | regulation, marketer, neurotechnology, advertiser, lack | Discusses regulations and ethical dilemmas in the use of neurotechnology in marketing. |
| 5 | Light blue - Theoretical concepts and development of the field | marketing, subject, code, author, self, role | It explores the conceptual development of neuromarketing, including its evolution and theoretical debates. |

Source: Own elaboration, based on results in Scopus.

The analysis of scientific production per country (see **Figure 3**) in the field of convergent technologies applied to neuromarketing reveals a geographical distribution dominated by the United States, with 13 contributions, followed by the United Kingdom (5) and Romania and Spain, each with 4 publications. Brazil, India, Turkey and Ukraine show a moderate presence, with 3 studies each, while countries such as France, Germany, Iran, Italy and the Netherlands have 2 publications respectively. In addition, a diverse set of nations, grouped in the "Other" category, contributes 11 additional studies, evidencing a global interest in the intersection between neuroscience, technology and marketing strategies. This distribution suggests that, although the leadership in research comes from

countries with advanced infrastructure in neuroscience and technology, there is a growing participation of emerging economies and regions with diverse dynamics of adoption of innovation in neuromarketing.
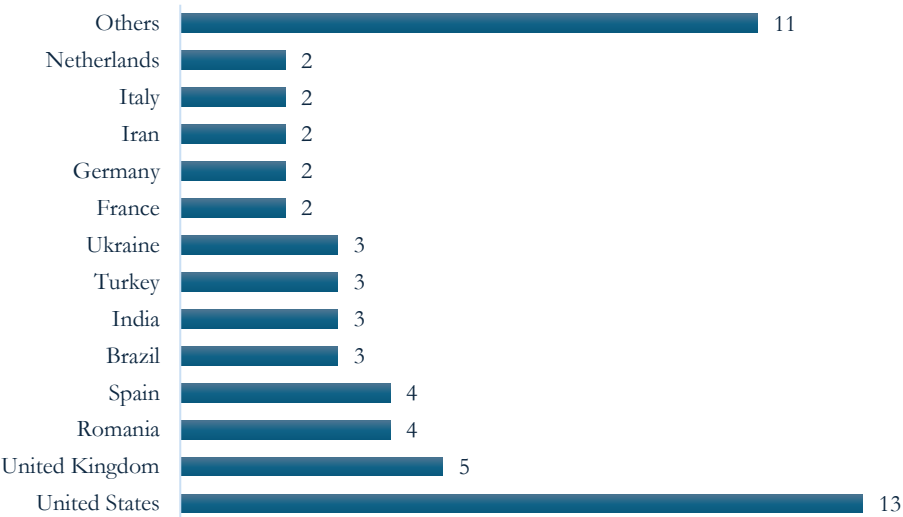


*Figure 2. Publications per country (2015 – 2024). Source: Own elaboration, based on results in Scopus.*

Related to the trend of publications in the period 2015-2024, there is a dynamic evolution (See **Figure 3**), with a moderate increase at the beginning (4 in 2015 and 5 in 2016), followed by fluctuations that reach their lowest point in 2019 (1 publication) and a prominent maximum in 2021 (11 publications). This marked variation suggests moments of growing academic interest and possibly greater availability of resources for research that combines technology, neuromarketing and ethics, contrasted with other periods of less activity. After the peak of 2021, production decreases in 2022 and 2023, and then experiences a significant rebound in 2024 (7 publications), which shows the cyclical and dependent nature of research in this field. Although consolidated data for 2024 are not available, the trajectory observed indicates that the area maintains a potential for reactivation and growth, driven by the constant interest in the convergence between neurosciences, technological innovation and ethical reflection.
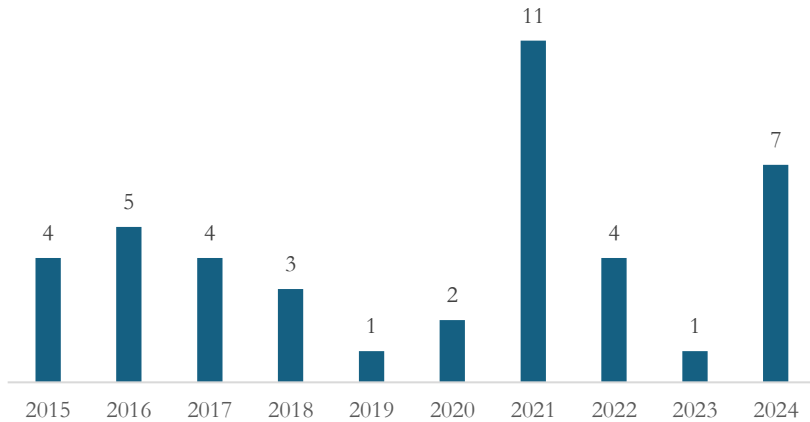
*Figure 3. Evolution in publications during 2015-2024. Source: Own elaboration, based on results in Scopus.*

The panorama of publishing areas (See **Figure 4**) reflects a predominance of studies oriented to the application of technology and neuromarketing in the business field, evidenced by the greater concentration in Business, Management and Accounting (24) and in Economics, Econometrics and Finance (17). However, interest in this topic also transcends the economic sciences, since Social Sciences (10) and Medicine (7) show relevant contributions, which suggests a broader approach that includes sociocultural and biomedical dimensions. Similarly, the presence of Computer Science (5) and Arts and Humanities (5), as well as the participation of more specific areas such as Neuroscience (4) and Decision Sciences (4), evidences the multidisciplinary nature of the field, in which quantitative, experimental and humanistic perspectives converge. Finally, the "Others" category (15) indicates the diversity of additional disciplines interested in this topic, confirming that the intersection between technology, neuromarketing and ethics attracts the attention of a wide range of specialties.
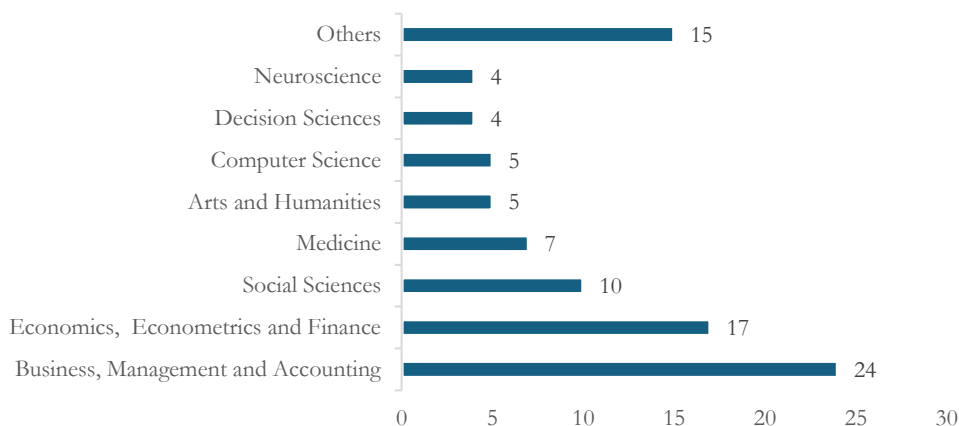
*Figure 4. Relation of publishing areas 2015 - 2024. Source: Own elaboration, based on results in Scopus.*

## 5. Conclusions

The convergence of advanced technologies in neuromarketing has fueled a debate about their ethical, regulatory, and scientific implications. The claims about decoding neural signals and predicting mental states cause worries about cognitive privacy and informed consent mainly within the domain of persuasive marketing (Ienca & Andorno, 2017a; Sieber, 2019). The lack of substantial regulatory protection creates a vacuum that could invite misuse of these technologies for exploitation in the art of manipulation of consumers and cognitive surveillance (Spahn, 2012; Wolpe, 2002).

Technologically, the recent progress in neuroscience blended with marketing owes its existence to tools such as the electroencephalogram (EEG) and AI and machine-learning strategies that promise to make the interpretation of neurophysiological responses much more accurate and efficient (Byrne et al., 2022; Georgiadis et al., 2022). However, the deployment of these technologies brings concerns such as transparency as well as algorithmic biases that may undermine the validity of findings and ethics in the use of them (Anupama & Rosita, 2024). In other words, emerging technological integration such as functional Near-Infrared Spectroscopy (fNIRS), neurofeedback, and VR/AR will actuate the pivot toward neuromarketing in exciting ways by enhancing what could be called the consumer experience (Y. Cho et al., 2021; Khodatars et al., 2021). It further embellishes the risk collection realm and use of neurodata in an age where lack of specific regulations that identify biometrics from personalized data makes such usual exploits that more alarming (M. Skriabin et al., 2021). To ensure a balance between innovation and ethics, it is imperative to establish regulations that regulate the collection and application of neuroscientific data in marketing, ensuring transparent practices and the protection of consumers against cognitive manipulation strategies.

What has been presented before is the basis for future research on regulative models, especially how cross-disciplinary supervising committees might be able to strike a balance between innovation and accountability. Sterz et al. (2024) propose that effective

human supervision in artificial intelligence systems needs interdisciplinary learning and would then draw from psychological, legal, philosophical, and technical standpoints applied particularly in neuromarketing to mitigate possible ethical risks. On the other hand, Raji et al. (2022) stress designing third-party audit ecosystems for artificial intelligence governance stating that the involvement of external bodies would increase accountability and consumer confidence with neuromarketing practices.

The analysis of the bibliographic production reveals a moderate growth in academic interest in convergent technologies applied to neuromarketing. The distribution by country shows that the United States leads with 13 publications, followed by the United Kingdom (5), Romania and Spain (4 each), and other countries with lower production. This suggests that research in this field is concentrated in nations with advanced innovation and technological development ecosystems. In terms of temporal evolution, a peak in production is observed in 2021 (11 publications), while in 2024 7 publications have already been registered, suggesting a continuity in interest in this topic. However, low production in some intervening years indicates that growth has not been steady.

According to the findings mentioned above, it is valid to reflect about the possible reasons that may explain the variations of publications and researches that connect topics like (Technology + Neuromarketing + Ethics); the peak in publications in 2021 would be attributable to increased access in postpandemic times to interdisciplinary funding on consumer behavior and accelerated digitalization. Secondly, the development of a specific cluster focusing on regulation and ethics indicates a growing awareness among the public regarding the use of neurotechnologies for commercial purposes, which probably energized studies that have undertaken legal or bioethical approaches. Besides, the lighter citation impact of some clusters-such as the theoretical-one could represent publication bias favoring applied empirical studies over critical perspectives or ones coming from emerging regions. Hence, the reflections made here reinforce the importance of continuing research on these topics.

In terms of areas of knowledge, neuromarketing with convergent technologies is mainly in the field of business and management (24 publications), followed by economics and finance (17), and social sciences (10). However, disciplines such as medicine (7), computer science (5) and neuroscience (4) also make a relevant contribution, which shows the multidisciplinary nature of this topic. Additionally, the analysis of the five clusters identified in previous studies highlights a diversified approach that encompasses the integration of technologies such as artificial intelligence, applied neuroscience, and ethics in the collection and use of biometric data. The presence of publications in areas such as engineering and psychology reinforces the importance of taking a holistic approach to neuromarketing research based on converging technologies.

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