EXPLORING THE ADVANCEMENTS OF NEUROMARKETING IN E-COMMERCE RESEARCH: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

E-commerce has emerged as a necessity and people have become part of its vast ecosystem. The dramatic rise in e-commerce adoption and adaption over the past ten years has prompted academic and professional marketing scientists to study customer behaviour in this area. Traditional research methods rely on self-reported data which is governed by conscious brain. The study of consumer behaviour using neuroscience is a field of study called neuromarketing. Despite the growing interest in neuromarketing in e-commerce research, there is still a gap in the literature that provides a comprehensive theoretical insight into the subconscious as well as conscious brain leading to behaviours of e-commerce consumers. By conducting a systematic literature assessment of peer-reviewed journal publications published from 2012 to 2022, this study seeks to analyse the developments in neuromarketing-based e-commerce research. The results show that the studies on e-commerce by neuromarketing on concepts like trust, purchase intention, emotional activation, product evaluation and consumer decision making, consumer purchase decision and rating. Reading deeper we analysed that area in the brain which is related to trust and cognition are primarily regions studied in the e-commerce. In this study, a direction for future studies and further recommendations has been provided.

Keywords: Consumer Behaviour, e-commerce, Marketing, Neuroscience, Neuromarketing.

INTRODUCTION

The rapid growth of e-commerce in recent years has been driven by advancements in internet technology and an increasing number of consumers turning to online shopping. The COVID-19 pandemic has further accelerated this trend, as lockdowns prompted many shoppers to shift their purchasing behavior to e-commerce.

According to Statista, the global market volume of e-commerce reached $1,412 billion in 2022, indicating a considerable rise in the number of consumers who are making online purchases. This growth has led to a shift in the way retailers approach sales, with many now embracing multi-channel strategies and constantly finding new ways to improve the online shopping experience for customers. The sudden increase in the adoption and adaptation of e-commerce in the last decade has led industrial and scholarly marketing scientists to investigate consumer behavior in this space. Hence, e-commerce consumer behavior has become a prominent subject of research in various scientific fields, including information systems, marketing, and psychology. Previous research in these fields focused on online shopping adaptation and utilization (Hansen, 2005), while more recent studies have focused on online purchase and repurchase behavior (Hsu et al., 2014; Chen et al., 2016). According to multiple studies (Jordao et al., 2017; Vecchiato & Tempesta, 2015), marketers use judgmental bias as a result of using traditional market research methods, which results in unsuccessful commercials or products. Traditional marketing methods have limitations in

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measuring consumer behavior, which is influenced by both rational (conscious) and emotional factors (subconscious).

This is where neuromarketing comes in as a solution. Neuromarketing techniques have the advantage of considering subconscious emotional aspects of decision-making (Zaltman, 2003; Ariely & Berns, 2010). Neuromarketing provides a valuable perspective on consumer behavior by combining a neuroscientific understanding of human decision-making and the application of neuro- and biometric technologies.

Neuromarketing techniques, which take into account subconscious decision-making, provide valuable insights into consumer behavior, but there is a dearth of research especially on the use of neuromarketing in the investigation of customer behaviour in e-commerce Although neuromarketing has the potential to offer useful insights into consumer behaviour in the context of e-commerce, there is a dearth of research focused on the comprehensive study of the application of neuromarketing in the e-commerce ecosystem as a whole. This is an area that could be beneficial to further study, as it would allow for a more detailed understanding at subconscious level of how consumers make decisions when purchasing products and services online. Recent years have seen a dearth of review studies that might offer guidance for future research, especially those that focus on neuroscience experiment as well as clustering of the trending concepts from a business and management perspective. This highlights the urgent need to critically analyse the barriers and comprehend why decision-makers are hesitant to employ it despite the numerous advantages supporting neuromarketing outcomes.

Despite this, no research has examined the impact and application of neuromarketing on ecommerce. Instead, they have studied the application of neuromarketing on consumer decisions in the offline setting. This discrepancy drives us to seek a solution to understand how neuromarketing affects consumers' purchasing intentions in online setting .In order to provide researchers and practitioners with a thorough orientation, this study analyses several research issues on neuromarketing and its application by gathering, evaluating, and summarising the available literature. To make it more precise we would be answering to the below four research questions.

RQ1: What are the prevailing theories, parameters, and conceptions in investigations of neuromarketing on e-commerce?
RQ2: What noteworthy themes may be gleaned from popular terms, parameters, and structures in studies on neuromarketing?
RQ3: What are the signal modality classification with respect to device and experimental protocol?
RQ4: What possible repercussions for practitioners and prospective future research avenues are there?

This study makes four original contributions to the body of literature by responding to the research topics. First, the systematic literature analysis assesses recent studies conducted between 2012 and 2022, identifies major trends outlines potential directions for further study. Secondly, the study compiled information from the thorough examination and offered detailed experimental as well as clusters on the basis of topics under which these experiments were done. Thirdly, from this study we would be able to identify the gaps and shortcomings of application of neuromarketing on ecommerce.

Lastly, managerial and theoretical recommendations have been given in the final section.

This paper underlines the neuromarketing effect as the core of consumer decision-making of the online customers and illustrates the frontiers of neuromarketing application in the ecommerce through a systematic review.

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Background

E-commerce: "E-commerce" or "electronic commerce" refers to online business transactions involving the purchase and sale of goods and services (Holsapple, 2000) (Kalakota, 1997). E-commerce is described by (Lawrence, 2003) as the exchange of goods and services over any of the internet's countless computer networks. In the context of our study, e-commerce refers to a wide range of online activities involving the exchange of value among 2 or more entities, including consumers (B2B, B2C), businesses (B2B) and governments (G2B, G2C) (Zwass, 2015)

Due to growing customer demand for e-commerce services and its ability to give firms a competitive edge, businesses are becoming more active in e-commerce (Gielens & Steenkamp, 2019); (Hamad et al., 2018); (Tan et al., 2019). However, because it incorporates quickly advancing, widely adopted, and extremely reasonably priced information technology, businesses find it difficult to apply this e-business model. As a result, companies are frequently compelled to modify their business plans to account for shifting customer expectations (Gielens & Steenkamp, 2019) (Klaus & Changchit, 2017) (Tan et al., 2019).

E-commerce is a vital part of the socioeconomic development of developing countries, according to policymakers, scholars, and practitioners over the past ten years(Avgerou, 2002). But little is understood about the circumstances and risks connected with the development of e-commerce in developing nations(Straub et al., 1997). The expanding global popularity of e-commerce is of great importance.

In 2021, 74% of people in the United States, 81% of people in Europe, and 69% of people in China reported making at least one online purchase.

Since the industry is still in its early stages of development, it is extremely competitive and pricey in industrialised nations. Marketplaces such as Amazon and AliExpress are booming, while many independent merchants struggle to differentiate themselves since brand and retail loyalty are diminishing and the cart abandonment rates in the business are significant. Through community creation (like ASOS Marketplace), loyalty programmes, and a smooth mobile and online user experience, brands may increase brand engagement. Over the past ten years, the e-commerce sector has evolved from a simple brick-and-mortar retail model to a shopping ecosystem with a range of devices and store layouts (Statista, 2022).

To improve the effectiveness and efficiency of the e-commerce business, we need to analyze consumer behavior using methodologies other than the traditional ones to gain a deeper understanding of it. In addition to conventional reporting, neuromarketing methods are available for e-commerce. There are literature studies for e-commerce and neuromarketing individually but are not integrated to show how much neuromarketing has already contributed to helping marketers understand the consumer behavior of e-commerce profoundly... Neuromarketing techniques are able to capture subconscious reactions, providing a more accurate picture of consumer behavior.

Neuromarketing

In 2002, Ale Smidt, a visionary marketer, created the term "neuromarketing" (Smidt, 2002). Despite The Economist acknowledging Jerry Zaltman for coming up with the idea to combine marketing with brain imaging technologies in the late 1990s (The Economist, 2004), it was Smidt who first coined the term. Neuromarketing is the study of how consumers' brains respond to marketing stimuli, such as advertising, packaging, and product design (Fisher, Chin, & Klitzman, 2010). To better understand customer behaviour, this integrative field blends marketing, psychology, and neuroscience. The first ever Neuromarketing

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Conference was hosted by Baylor College of Medicine in 2004, which brought together experts from various fields to discuss the latest research and developments in the field (Baylor College of Medicine, 2004). The conference was a turning point for neuromarketing and marked the beginning of its rise to prominence in academic and professional circles. Dr. Eric Kandel, a Nobel Laureate in Physiology and Neuroscientist, stated that understanding the human mind from a biological perspective has become one of science's main goals in the 21st century (Kandel, 2013). He recognized the importance of neuromarketing in understanding consumer behavior and its potential impact on the field of marketing.

In 2012, Martinez published his book "The Consumer Mind," in which he divided consumer brains into four groups based on their response to marketing stimuli (Martinez, 2012). He emphasized that there is a disconnect between what people think, say, do, and feel and that "consumers contradict themselves, claiming what they want but doing what they feel," which is a basic component of traditional marketing research. Neuromarketing helps to bridge this disconnect by providing insights into how the brain processes marketing stimuli and influences consumer behavior.

In 2001, Atlanta a marketing firm Bright House launched a neuromarketing division, bringing attention to the integration of neuroscience and marketing in the fields of business, research, and media. The company applied the methods of the brain to marketing, answering questions from the advertising world using neurology lab techniques (Bright House, 2001). According to the International Journal of Psychophysiology, neuromarketing is "the application of neuroscientific methods to evaluate and comprehend human behaviour in relation to markets and marketing exchanges" (International Journal of Psychophysiology, n.d.).

In recent years, neuromarketing has been used to improve product design, advertising campaigns, and packaging, as well as to understand consumer behavior in various contexts, such as online shopping and virtual reality. The field is still in its early stages, but it holds great promise for the future of marketing research and consumer insights.

Neuromarketing Tools

The advancements in neuroscience, mostly through neuroimaging techniques, were one of the major factors contributing to neuromarketing's legitimacy. (D. A. Baker et al., 2017). Neuroscience is the base of neuromarketing being researched theoretically and neuroimaging techniques are employed in this developing discipline to test hypotheses, advance our understanding of the subject, or examine how marketing stimuli affect consumer brain function. Zurawicki et. al., distinguishes between the devices utilized in neuromarketing research that record brain electric activity and those that record metabolic activity (Zurawicki, 2010).

Each technique and its experimental process will be further presented in the parts that follow.

Metabolic Activity of the Brain

Positron Emission Tomography (PET)

A medical imaging method known as positron emission tomography (PET) creates fine-grained images of the body's physiological processes by using small amounts of radioactive substances known as radiotracers. The radiotracers are injected into the body and then emit positrons, which are a type of subatomic particle. These positrons interact with electrons in the body, producing gamma rays that can be detected by special cameras called

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PET scanners. By analyzing the patterns of gamma rays, doctors can get a detailed view of how different parts of the body are functioning.

One of PET's key benefits is its ability to reveal details on the body's metabolic processes, which aids medical professionals in the detection and diagnosis of a variety of illnesses, such as cancer, heart disease, and neurological problems. For example, a study by Kohno et al. (2017) showed that PET scans can be used to detect changes in the brain that occur in Alzheimer's disease, which can help doctors diagnose the condition earlier and monitor the effectiveness of treatment.

To give a more complete picture of the body, PET scans are frequently combined with other imaging methods like computed tomography (CT) or magnetic resonance imaging (MRI). However, PET scans do have some drawbacks. One of the main challenges is that the radiotracers have a limited lifespan, which means that they need to be produced and administered very quickly. Additionally, PET scanners are expensive, and the procedure can be costly. According to a study by Muehllehner et. al. (2016), the cost of a PET scan can range from $2,000 to $6,000, based on the facility's location and the type of scan. *(functional).*

Magnetic Resonance Imaging

Another imaging method used in medicine, functional magnetic resonance imaging (fMRI), can produce finely detailed pictures of the brain and spinal cord. It functions by tracking variations in blood flow brought on by brain activity. Before releasing radio waves that trigger the body's protons to produce signals, the fMRI scanner aligns the body's protons with a powerful magnetic field. The scanner then detects these signals and uses them to create detailed images of the brain.

fMRI has a number of advantages over other brain imaging techniques, such as CT or PET. It is non-invasive, meaning that it does not require the injection of any contrast agents or the use of ionizing radiation. Additionally, it can deliver accurate real-time images of the brain's activity and is generally safe. For instance, Huettel et al. (2004) used fMRI to examine the neurological basis of decision-making and discovered that various brain regions are active at different points during the process.

Studying brain function in healthy individuals and those with neurological or mental illnesses is one of the principal applications of fMRI. fMRI can help researchers understand how the brain processes different types of information and how it is affected by different conditions. In order to better understand how people react to various products or messages, neuromarketing studies are also using functional magnetic resonance imaging (fMRI) to monitor brain activity as participants engage in activities or are exposed to marketing stimuli. For instance, Koivisto et al. (2011) used functional magnetic resonance imaging (fMRI) to examine how different types of commercials affected people's brain activity and discovered that advertisements that elicited good feelings were more likely to be recalled.

However, fMRI is not without its drawbacks. The procedure can be expensive and the machines are large and complex. Additionally, participants must remain still during the scan, which can be uncomfortable or even painful. Ongoing efforts are being made to improve the technique, such as developing the ability to use fMRI scanners while sitting or standing, and increasing the temporal and spatial

Electric Activity in the Brain

Transcranial magnetic stimulation (TMS): A technique called transcranial magnetic stimulation (TMS) uses magnetic induction to change the activity of specific brain regions

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that are located 1-2 millimetres inside the skull and are not connected to the neocortex. According to Perrachione et al. (2008), TMS tracks the general neuronal activity of the brain, and new technology now makes it possible to target lower brain regions as well. Compared to PET or fMRI scanners, the device is less expensive. Near the subject's head is a plastic casing with an electric coil inside of it. A magnetic field is produced by TMS and travels through the brain, letting either the momentary activation of neurons (using high frequency) or the momentary suppression of neuronal activity (using low frequency) in particular areas of the brain tissue (using low frequency)(Perrachione & Perrachione, 2008).

Electroencephalography

Electroencephalography (EEG) is a medical imaging technique that measures brain waves by attaching electrodes to the subject's scalp using bands or helmets. According to Morin (2011), this technology allows for the measurement of brain waves at rates of up to 10,000 times per second while the subject is connected to various levels of stimulation. EEG is more accessible, less invasive, and less expensive than other techniques, and it provides improved validity for identifying psychopathologies and measuring emotional kinds (Allen & Kline, 2004). However, the limitation of this approach is that it can only record electrical impulses that are more surface-level and cannot measure deeper brain areas. Compared to fMRI, EEG offers a superior temporal resolution but a less accurate spatial resolution.

Magnetoencephalography (MEG)

The magnetic field generated by brain activity and electrochemical impulses between neurons is expanded and mapped in magnetoencephalography (MEG), another medical imaging technology. According to Morin (2011), MEG has the excellent temporal resolution, like electroencephalography, but its spatial resolution is better than EEG's, making it less suitable for monitoring subcortical areas and deeper brain regions. MEG research, in contrast to EEG, without touching the scalp, uses incredibly sensitive sensors to measure the electromagnetic field. However, EEG is more widely used than MEG because it is less expensive to acquire the necessary tools and conduct a magnetoencephalography session (Crease, 1991)

Peripheral Brain Activity

Eye tracking: Eye tracking is a method of measuring the gaze of a person by using a device that tracks the movement of the eyes. This method, according to Laubrock et al. (2007), enables the investigation of behaviour and cognition without establishing brain activity. Researchers can learn more about how a person receives visual information and how they react to various stimuli by observing the location, duration, and direction of the subject's gaze as well as changes in the pupil's dilation. Fixations and saccades are the two main types of eye movements. While a saccade is a change in position, a fixation happens when the eye focus remains fixated on a single object. By analyzing the scan path, which is the collection of fixations and saccades that result, researchers can examine visual perception, cognitive purpose, interest, and salience (Zurawicki, 2010).

Skin Conductance (GSR/EDA)

By monitoring changes in the electrical conductance of the skin, the Skin Conductance (GSR/EDA) approach evaluates emotional arousal. The brain reactions that come before certain emotions, such as joy, grief, wrath, disdain, indifference, and fear, can be

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discovered with this technology. The reactions shown on people's palms are closely related to the central nervous system, claim Banks et al. (2012).

Facial motion recognition

Electromyography, often known as face recognition, is a method that monitors both voluntary and involuntary facial movements that signify conscious and unconsciously held emotional states. According to Ohme et al. (2013) and Dimberg et al. (2000), every emotion is defined by a distinct combination of facial activity. Small surface electrodes are typically used to record facial electromyography (Face EMG) on each side of the face, capturing activity from particular muscles that are important in the display of simple emotions (Cacioppo et al., 1986).

Materials and Method

The study's objective was addressed using a systematic literature review because it offers a complete and systematic method for the search strategy and article selection. According to Snyder (2019), by using the inclusion criteria defined during this review process. This approach was determined to be the most suitable for achieving the study's objectives. This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) declaration of best practises for systematic reviews Figure 1.

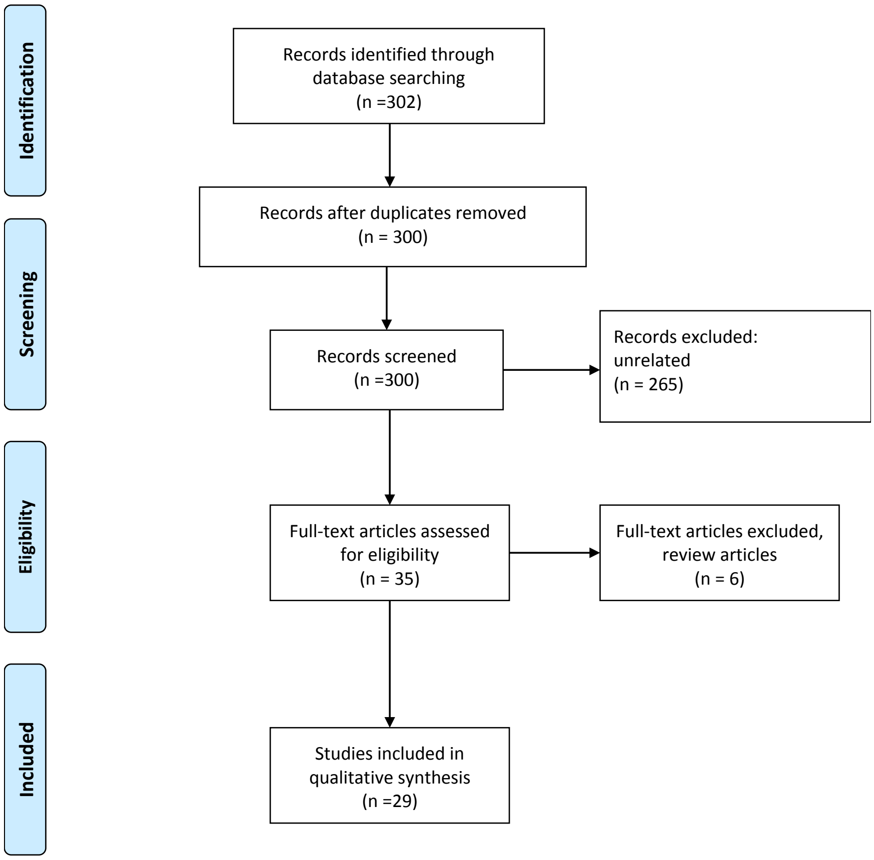

FIGURE1
PRISMA FLOWCHART FOR THE ARTICLE SELECTION PROCESS

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A research-based strategy for performing a systematic literature review, the PRISMA process shows the information flow through the different phases, the number of items that were included or omitted, and the justifications for those inclusions and exclusions given by Moher et al. in 2009. The literature review was conducted using PRISMA as shown in fig 1. According to the PRISMA recommendations, we used four electronic databases in this work to include empirical, conceptual, or a mixture of these two which were published in English language research articles that were focused on the application of neuromarketing on e-commerce. A total of 302 studies were completed, with 29 of them meeting the inclusion requirements. The first filter includes the study's title, abstract, keywords, and references; the second and third filters, respectively, including the introduction and conclusion. The databases used in this study were EBSCO, Scopus, Emerald Insight, and Web of Science.

The searched journal articles were peer-reviewed in the English language and published from 2012 to 2022. The searched terms and phrases are (((neuromarketing OR (consumer AND neuroscience)) AND ((electronic AND commerce) OR e-commerce OR e-procurement OR Oscommerce OR e-business)). A total of 302 (Scopus, Emerald Insight, EBSCO, and Web of Science) articles were found. Out of which two articles were deleted because they were duplicates.

Screening of the articles included examining the records obtained in the initial search. 265 articles were excluded due to the exclusion criteria.

We deleted 6 review articles. The criteria for inclusion were i) Study should include one of the tools used in neuromarketing, ii) Study should be empirical or conceptual, iii) Study should be done on human subjects iii) Study should only include online content. , we can ensure that the articles we select are pertinent to our objective.

Results

In this section result of the literature review is presented. 29 is the total number of papers that are analyzed and classified on the country of origin, publication year, research methodology, different signal modalities used in the research, subject information, experiment, and type of analyses.

1) Year-wise

Figures 2 & 3 displays the research work distribution by year. Since 24 studies, or 82 % of the total, were published between 2017 and 2021, it is obvious from Fig. 2 that the research on e-commerce utilizing neuromarketing as a technique has been expanding steadily.

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The maximum number of studies done in 2018, accounts for 34% of the total.

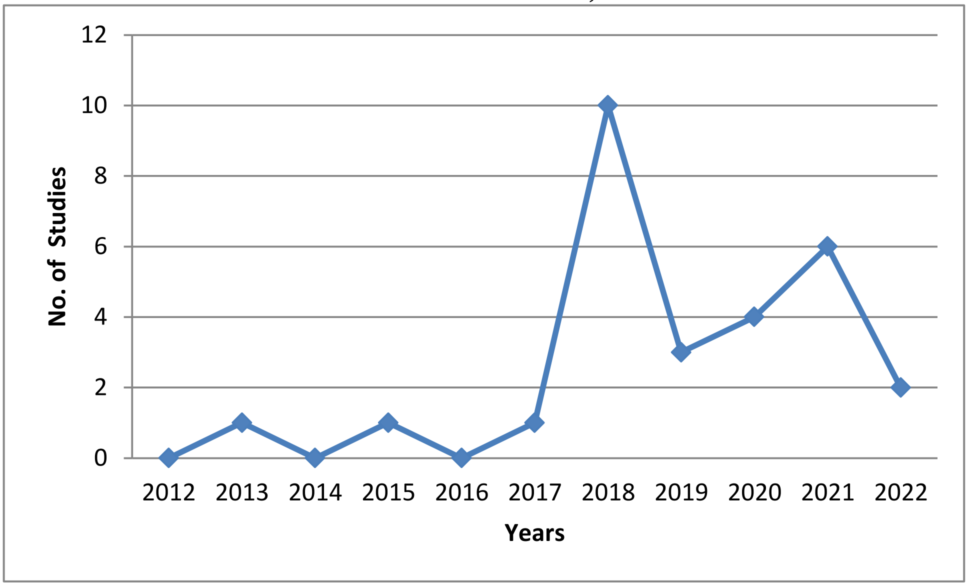

FIGURE 2
DISTRIBUTION OF SELECTED 29 ARTICLES YEAR-WISE FROM 2012- 2022

Country-wise origin

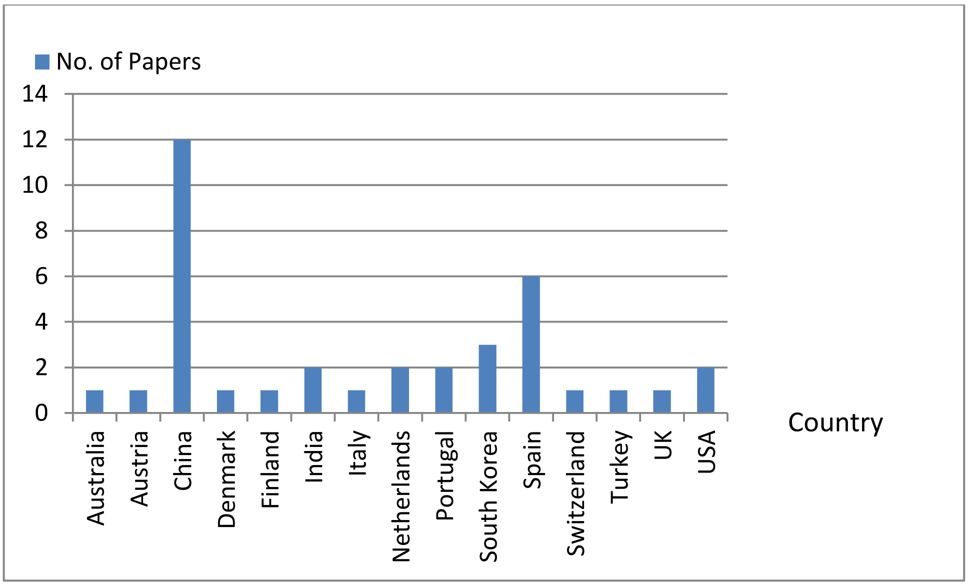

FIGURE 3
ORIGIN-WISE CLASSIFICATION OF STUDIES ON THE CONTRIBUTION OF NEUROMARKETING TO E-COMMERCE

The chart makes it evident that China has performed the majority of the research on e-commerce utilizing neuromarketing. According to data from the Statista Digital Market Outlook, with a forecast industry volume of US$1,412.00 billion in 2022, the majority of revenue is produced in China, which captures the largest share of the world's e-commerce market. And because of that greatest numbers of studies are being done in China. With that, it can be inferred highest number of studies being done on e-commerce and neuromarketing is

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evolving and China is using that technology before other countries. Spain being the second highest where most number of studies being done.

Source based

Figure 4 shows the journals of the papers that have been collected for the study. It can be inferred from fig 4 that the European Journal of Marketing which is a marketing journal is the journal with the maximum number of papers taken for the study. Frontiers in Neuroscience are the Neuroscience journal that has the second highest number of papers. Figure 4 illustrates how research publications are distributed among the journals' areas of study. It is visible that this study is relevant to IT and Neuroscience along with marketing. So, there are numerous studies in the field that have been published in IT journals, because of the interdisciplinary nature of the study. In the future, for publishing the work researchers can approach the IT and neuroscience domain.

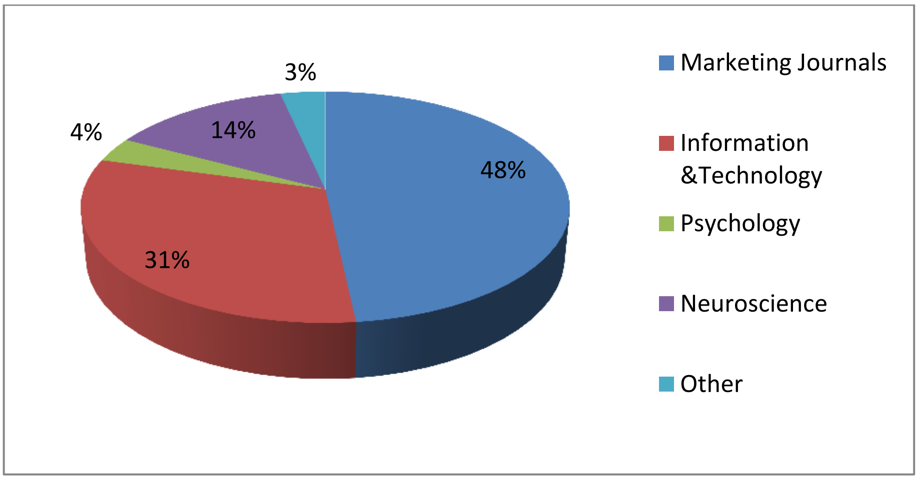

FIGURE 4
DISTRIBUTIONS OF ARTICLES BASED ON DOMAINS OF THE JOURNAL

Signal Modality

From figure 5, it can be inferred that 41 % of the total articles were using EEG Signals, which is followed by Eye Tracking and fMRI signals being 25% and 19% respectively. Studies that used electrodermal activity or galvanic skin response (EDA/GSR) and Functional near-infrared spectroscopy (fNIRS) have percentages of 9% and 6%. Among the reviewed articles most researchers have used EEG and Eye Tracking.

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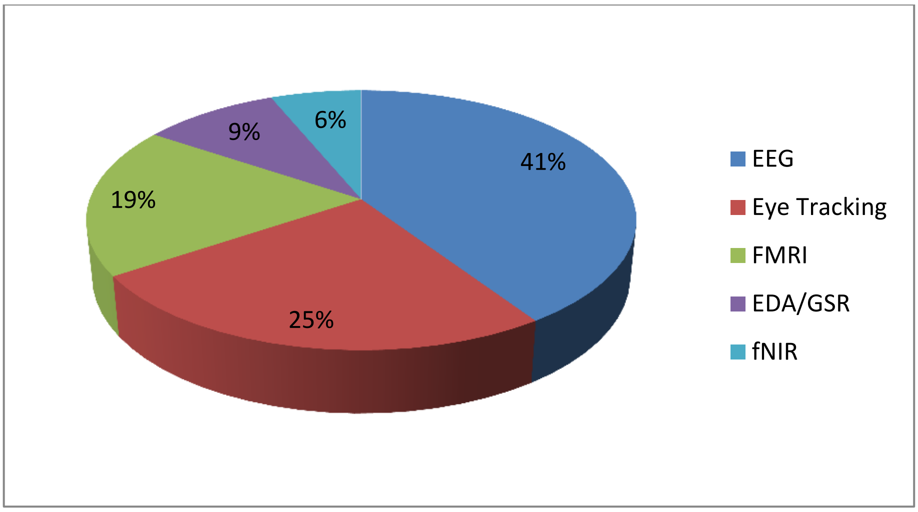

FIGURE 5
DISTRIBUTION OF ARTICLES BASED ON THE SIGNAL MODALITY USED BY RESEARCHERS

Table 1 shows the devices used to record the signals, the device that has been mostly used is Emotiv EPOC and its different versions for EEG and eye trackers from TOBII have been widely used.

Table 1
MODALITY AND DEVICES EMPLOYED IN VARIOUS NEUROMARKETING STUDIES

S.no.	Modality	Device Specification	Reference
1	EEG	Emotiv EPOC+	(Yadava et al., 2017), (Kumar et al., 2019)
		Neurone EEG/ERP	(Qiu, 2018)
		Net Station 4.1.1 (Electrical Geodesics Inc., Eugene, Oregon, USA)	(Shen et al., 2018), (Zhao, 2022)
		ESI	(Qing et al., 2019)
		NeuroScan	(Qing et al., 2019)
		NeuroSky Mindset EEG headset	(Liang et al., 2021)
		NeuroScan SynAmps2 Amplifier (Curry 7, Neurosoft Labs, Inc., Virginia, USA)	(C. Wang et al., 2018)
		NeuroScan SynAmps2 Amplifier (Curry 8, Neurosoft Labs, Inc., Virginia, USA)	(J. Wang et al., 2021)
		Neuron-Spectrum 3 (Neurosoft Lt, Russia) and 21-Channel Digital EEG Systems	(Yen & Chiang, 2020)
2	Eye Tracking	Tobii T120 eye-tracker	(Ahn et al., 2018)
		Tobii X2-60 eye-tracker	(Karmarkar et al., 2021)
		Eyelink 1,000 Plus	(Mo et al., 2021)
		SMI Hi-Speed iView X infrared monocular eye tracker	(Q. Wang et al., 2020)
		Tobii T60 eye-tracker	(Muñoz-Leiva et al., 2018)
		SMI Red500 remote system [SensoMotoric Instruments (SMI), Berlin, Germany]	(Muñoz-Leiva et al., 2021)

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3	fMRI	3.0T MRI scanner (Siemens Magnetom Trio system) equipped with a 32-channel bridge head coil	(M. Y. T. Hsu & Cheng, 2018)
		3.0 Tesla MRI scanner (Ingena 3.0T CX, Philips Healthcare, Best, Netherlands)	(Kim et al., 2021)
		3T fMRI scanner (Magnetom Trio, SIEMENS, Erlangen, Germany)	(Hubert et al., 2018)
4	fNIRS	fNIRS Devices LLC (Potomac, MD	(Çakir et al., 2018)
		fNIRS system (Biomedical Optics Lab, Korea University)	(Cha et al., 2020)
5	EDA/GSR	Bluetooth Shimmer3	(Herrando et al., 2022)
6	Reaction Time (RT)*[1]	E-Prime 2.0 Software	(Kim et al., 2021)

By Subject Information

From the articles, variation in the number of participants depends on the field and type of experiment. It is clear from Table 2 that the lowest number of participants is 9 (Wang et al., 2021) and the highest number of participants is 97(Guerreiro et al., 2015). Participants have given written consent in every experiment (Shen et al., 2018). We can figure out from Table 2 the mean age of participants is between 25 to 30 years and the age range is from 18 to 57 but mostly lies between 18 to 40years. Approximately all of the participants were right-handed, and some were assessed using Oldfield's 1971 Edinburgh handedness survey (Çakir et al., 2018). In most of the papers ratio of males to females is the same i.e. they have taken an equal number of males and females to understand the population precisely. Participants have been excluded based on not being able to calibrate in eye tracking, which is also a signal of impaired eye vision, not having high-level computer expertise, spending less than ten hours a week online, and having made at least one purchase in their lifetime. (Luis Alberto et al.), psychiatric Disorders (Çakir et al., 2018), poor posture experimenting (Guerreiro et al., 2015), a vision that is normal or has been corrected (Guerreiro et al., 2015; Q. Wang et al., 2020; M. Y. T. Hsu & Cheng, 2018; Shen et al., 2018; J. Wang et al., 2021). Standard exclusion criteria for neuroscientific research, such as those relating to neurological conditions and legal age restrictions (Belanche et al., 2020), having astigmatism and myopia of more than 350 degrees in the left eye(Q. Wang et al., 2020), they have taken any medications or experienced any brain damage, as drug use or lesions might skew brain imaging results (Hsu & Cheng, 2018), pregnancy(Kim et al., 2021), excessive recording artifacts while recording EEG signals (Wang et al., 2018; Wang et al. 2021). In some papers, the participant's information have been revealed like they have been provided some reward in the form of money and whether they have voluntarily participated in the experiment or not (Çakir et al., 2018; Shen et al., 2018).

Table 2
EXPERIMENT PROTOCOLS UTILISED IN THE CHOSEN PUBLICATIONS TO RECORD DIFFERENT MODALITIES

S.no.	Reference	Data Collection	No. of Participa	Age Group	Gender	Numbe r of	Modality	Record ing

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		Method	nts			Stimulus		Frequency
1	(Casado-Aranda et al., 2018)	Experiment	30	Mean Age -36.59	14 F, 16 M	-[1]	fMRI	-
2	(Çakir et al., 2018)	Experiment	33	18-46	17 F, 16 M	-	fNIRS	-
3	(Yadava et al., 2017)	Experiment	25	18-38	-	42	EEG	-
4	(Ahn et al., 2018)	Experiment	48	<20 to >40	34 F, 36M	40	Eye Tracking	-
5	(Guerreiro et al., 2015)	Experiment	97	26 to 45	28 F , 20 M	4	Eye Tracking+ EDA	EDA-2000 Hz
6	(Belanche et al., 2020)	Experiment	42	18 to 46	21 F, 21 M	24	EEG+ GSR	-
7	(Karmarkar et al., 2021)	Experiment	66	18 to 40	-	36	Eye Tracking	-
8	(Casado-Aranda et al., 2019)	Experiment	30	Mean Age 25.04	15 F, 15 M	48	fMRI	-
9	(Mo et al., 2021)	Experiment	20	Mean Age 24.3	8 F, 12 M	-	Eye Tracking	2000 Hz
10	(Valentini et al., 2018)	Experiment	61	18 to 30 26.5	-	-	-	-
11	(Valentini et al., 2018)	Experiment	90	Mean Age 22.69	44 F, 46 M	16	Eye Tracking	500 Hz
12	(Q. Wang et al., 2020)	Experiment	31	Mean Age 20.39	4 F, 5 M	-	EEG+GSR +vEOC	-
13	(Herrando et al., 2022)	Experiment	84	16 and 57 Mean Age 34.11	42 F, 42 M	-	Eye Tracking	60 Hz
14	(Muñoz-Leiva et al., 2018)	Experiment	51	23-25 Mean age, 24.5	25F , 26 M	20	FMRI	
15	(Qiu, 2018)	Experiment	40		-	-	EEG	500 Hz
16	(Shen et al., 2018)	Experiment	22	21-34 (Mean age 25)	10 F, 30 M	96	EEG+EOG	500 Hz
17	(Liang et al., 2021)	Experiment	70	18 to 30	36 F, 34 M	4	EEG+Questionnaire	-
18	(Kim et al., 2021)	Experiment	39	20 to 29	39 F, 0M	42	FMRI + Reaction Time	-
19	(J. Wang et al., 2021)	Experiment	9	20–26 years (mean age = 23 ± 1.26 years)	9 F, 10 M	2	ERP	1,000 Hz
20	(C. Wang et al., 2018)	Experiment	30	18 to 25 Mean Age 20.53	15 F, 15 M	160	EEG	500 Hz
21	(Zhao, 2022)	Experiment	24	21 and 30 (Mean age 25)	11 F, 13 M	-	ERP	500 Hz

[1] Data not available

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22	(Muñoz-Leiva et al., 2021)	Experiment	48	17 and 53 years of age (Mean age: 34.6 years)	24 F, 24 M	4	Eye Tracking	(500 Hz
23	(Hubert et al., 2018)	Experiment	20	30-35 Mage = 31.8 years	10 F, 10 M	120	fMRI	-
24	(Yen & Chiang, 2020)	Experiment	30	21 to 24 years (Mean = 21.55 years	18F, 12 M	-	EEG	5000 Hz
25	(Adhami, 2013)	Experiment	30	25 to 45	-		Eye Tracking + EEG	-
26	(Cha et al., 2020)	Experiment	56	20 to 29	23 F, 33 M	5	fNIRS	8-10 HZ
27	(Kumar et al., 2019)	Database	40	18 to 38	15 F, 25 M	15	EEG(dataset)	-
28	(Qing et al., 2019)	Database	32 & 15	-	-	40	EEG DEAP & SEED Database	1000 Hz
29	(van Zeeland & Henseler, 2018)	Conceptual	-	-	-	-	Conceptual Paper EEG	

Experiment Based

The subjects in the experiments conducted in the studies were given a comprehensive explanation of the method before it started and completed the consent form (Casado-Aranda et al., 2018). The studies were conducted in a laboratory environment to minimize external distractions (Guerreiro et al., 2015; Ahn et al., 2018). Participants arrived one hour early for the fMRI, eye tracking task, etc. task and were seated in front of the equipment (Casado-Aranda et al., 2018; Casado-Aranda et al., 2019; Ahn et al., 2018). The tasks were completed by participants while viewing them on a computer screen and following instructions that required use of keyboard and mouse (Karmarkar et al., 2021). The software was used for both stimuli presentation and data collection (Ahn et al., 2018). Eye tracking was calibrated and managed by the software (Ahn et al., 2018). Participants were given practice tasks to familiarize themselves with the methodology. Responses were collected through various modalities after exposure to stimuli, followed by self-report questionnaires.

By Stimulus

The experiments conducted included the use of visual and textual stimuli to study the effects on the participants. Visual stimuli included sample replicas of three e-tourism websites, auto-visual ads (Muñoz-Leiva et al., 2018; Muñoz-Leiva et al., 2021), actual online apparel products (Mo et al., 2021), and pictures of Chinese fashion models (Q. Wang et al., 2020). These visual stimuli were presented using the e-prime 2.0 program. The textual stimuli included a series of original reviews taken from TripAdvisor (for a hotel and a paella restaurant) and Amazon (for a computer and sneakers) (Herrando et al., 2022; Shen et al., 2018).

Classification and Statistical Analysis

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Classification

Only 2 of the 13 articles that used EEG signals for analysis used machine learning algorithms like Artificial Neural Networks (ANN), Support Vector Machines (SVM), Hidden Markov Models (HMM), Discrete Wavelet Transformations (DWT), Decision Trees, K-Nearest Neighbors (KNN), and classification techniques like K-fold cross-validation and Random Forest. Signal averaging has been accomplished using S-Golay filters.

Statistical Analysis

The majority of data analysis in neuromarketing research involves pre-processing, analytical methods, interpretation of data (containing evaluation and neurobiological data processing), and harmonization. According to Reimann et al. (2011), pre-processing is divided into four stages: smoothing, normalising, head motion correction, and timing correction (the interval between the appearance of a stimulus and the signal of its impact being recorded) (noises are removed using Gaussian filters). Finding the regions of the brain where a time series significantly corresponds with an experimental condition using statistical analysis (fitting a general linear model). Luis-Alberto Casado-Aranda et. al. used the general linear model (GLM) method to distinguish between stimulus-induced signals and noise. At the single-subject level, using a GLM, imaging data were analyzed (Hesun Erin Kim et. al.). Most of the fMRI studies have used the GLM approach.

By rectifying complimentary sources and connecting them to the data obtained using neuroimaging, data interpretation should either corroborate or infirm the research's premise. Vechiatto et al. (2010) emphasise several considerations with regard to the adoption of suitable statistical methodologies given that neuromarketing data can contain errors and should be checked prior to analysis. Out of 29 articles, 23 articles have carried out statistical analysis .p-values have been calculated to find out the significant features. Out of 23 articles, EEG/ERP (Event-related Potential) was only used in 11 studies. ANOVA was used to investigate the beta and theta oscillations in the left frontal area of the brain (Carolina Herrando et. al.). Most of the analyses were done using different versions of SPSS, like SPSS 19.0 (IBMSPSS Statistics 19),(Yongchao Shen et. al.), SPSS 25.0 (SPSS Inc., Chicago, IL, United States), (Hesun Erin Kim et. al.), fNIRS analysis by IBMSPSS v24.0.(Murat Perit Çakir et. al),for eye tracking SPSS, Version 23.0 tests the mediation hypotheses(Francisco Muñoz-Leiva et. al.)

For the purchase rate, repeated-measures ANOVA was used (Yongchao Shen et. al.). ANOVA and specially repeated-measure have been used to analyse data in most of the studies and with different tools.

The survey data were then evaluated using SmartPLS-supported partial least squares structural equation modelling (PLS-SEM) by Chiahui Yen, Ming-Chang Chiang, Ting-Peng Liang, et al.

Discussion

This study examined the recent 29 publications on the application of neuromarketing to e-commerce. The majority of the studies on this topic were released between 2017 and 2021, with the most studies being conducted in 2018. The findings also revealed that China, followed by Spain, had the most studies conducted in this area. Journals like Frontiers in Neuroscience, the European Journal of Marketing, and other journals in IT and neuroscience published the studies. The majority of the studies used EEG signals (41%) followed by Eye Tracking (25%) and fMRI signals (19%).

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The Emotiv EPOC device was most frequently used to record signals, and participants in the research ranged in age from 18 to 40, with a mean age of between 25 and 30. The experiments were conducted in a laboratory setting to reduce external distractions, and participants were thoroughly explained the method before the experiment and completed a consent form. The results of this literature study offer insightful information about the application of neuromarketing in e-commerce and indicate that the sector is expanding quickly, particularly in China. The findings also emphasise the value of undertaking additional study in this field to better comprehend how neuromarketing affects e-commerce. Further, studies could be classified according to the major trends spotted which are as follows,

Trust

According to several studies (Cummings and Bromiley, 1996; Handy, 1995), trust lowers transaction costs because it fosters open, meaningful, and impactful information flow while also boosting relationship security and confidence. Trust is crucial in transactional interactions because it helps to manage uncertainty and creates more chances for trading partners to work together more effectively.

A study by Qiu (2018) found that trust is the cornerstone of the entire consumer decision-making process, directly influencing the buyers' purchasing decisions, lowering transaction costs, and reducing speculative behaviour. Research from other studies has also revealed the importance of trust in consumer decision-making. Hubert et al(2018) .'s study also discovered that while hedonic and cautious shoppers' neural activation patterns are comparable, there are differences in the intensity of patterns in parts of the brain that are closely related to impulsivity and trust.

The study by Casado-Aranda et al. (2019) used functional neuroimaging to examine the neural correlates of trust and consumer decision-making in relation to different types of assurance in online shopping contexts. The study found that seals of approval were the most effective form of assurance in terms of activating brain regions associated with reward and expected values, while assurance phrases activated fewer brain regions and had lower trust scores. Products with rating systems, on the other hand, activated brain regions associated with uncertainty, pessimism, and risk.

According to the study, consumer impulsivity can have a big impact on how well online offers are evaluated. Hedonic and cautious shoppers showed similar cerebral activation patterns, but there were differences in the intensity of these patterns in regions of the brain connected to impulsivity and trust. The study investigated the brain correlates of trust in online environments and consumer impulsiveness using an experimental design that integrated behavioural and fMRI data.

Additionally, anthropomorphism, social presence, expertise, and in formativeness were all proven to have an effect on consumer trust in chatbots, which in turn has an effect on purchase intention, according to Yen and Chiang (2020).

Purchase Intention

The goal of customers to engage in an exchange relationship at online stores, such as information sharing, maintaining business contacts, and creating commercial transactions, is known as the intention to transact or purchase intention (Zwass, 1998). The effect of dynamic pictures on consumer purchase intention for aquatic products was examined in the study by J. Wang et al. (2021). The study found that participants had a higher purchase intention for products depicted in dynamic images, as compared to static images. A decrease in N2 amplitudes and latency, as well as an increase in LPP (late positive potential) amplitude, as

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well as a reduction in cognitive conflict and happy sensations in consumers, were shown to be the effects of dynamic images in the study.

Another study by Yen and Chiang (2020) also found that trustworthiness, social presence, competence, informativity and anthropomorphism and all have an impact on consumer trust in chatbots. The study found that these factors can influence consumers' desire to make purchases through chatbots. The results show that the superior temporal gyrus and the dorsolateral prefrontal cortex are significantly linked to building a trusting relationship by assuming chatbots would impact future behaviour.

In summary, both studies indicate that trust and positive emotions play a significant role in consumer decision-making, and that dynamic images and chatbot design can affect these factors, leading to increased purchase intention.

Emotions

The study by Casado-Aranda et al. (2018) used functional neuroimaging to investigate the neural correlates of perceived safety in e-payments. The study found that brain regions associated with the processing of unpleasant emotions were highly activated by perceived unsafe e-payments, while reward prediction areas were strongly activated by secure e-payments.

In a similar manner, Guerreiro et al. (2015) used physiological techniques like eye-tracking and skin conductance monitoring to comprehend how emotional arousal, enjoyment, and attentiveness play a part in the success of emotionally charged marketing campaigns. The study found that physiological responses are significant predictors of altruistic behavior in both hedonic and utilitarian situations, and that the use of physiological tests can provide insight into the unconscious factors that influence human decision-making.

The bottom-up visual attention bias is caused by contrast between clothing qualities, not by the absolute stimulus strength of the feature, according to Mo et. al. study 's from 2021. Garment concerns have the ability to drastically change a person's emotional experience when paired with other clothing components. The study by Herrando et al. (2022) also discovered that physiological assessments (through skin conductance response) demonstrate that the observer's emotional arousal is similar to that of the object of observation.

Negative Online Consumer Ratings OCRs are linked to arousal activation and pleasure in the viewer, whereas positive OCRs are linked to arousal deactivation and dissatisfaction, according to neurological studies (via electroencephalography), which indicate the valence of arousal. The study by Qing et al. (2019), which employed weighting coefficients based on the correlation coefficient and the entropy coefficient, significantly increased the accuracy of EEG-based emotion identification. The study gradually activated emotions and discovered that, even when it only enhances apparent movement, visual dynamism can induce positive sensations about the objects and raise purchase intention.

Finally, J. Wang et al. (2021) study found that picture dynamism can elicit favorable feelings regarding the goods and enhance buy intention. The purpose of the study is to demonstrate the value of using a neuroscience perspective to understand consumer cognition and emotional product evaluation.

These researches show how neuroimaging, physiological measurements, and other methods can help us understand how consumers make decisions, experience emotions, and the neurological mechanisms that underlie these activities.

They also suggest that important influences on customer buying decisions include emotions, safety, and trust.

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Product Evaluation

According to studies by Qiu (2018) and Kim et al. (2021), for consumers making purchases, authenticity is really important. Qiu's study found that when a product is perceived as authentic, consumers are more likely to make a purchase decision, with the decision purchase rate being greater in true evaluation scenarios compared to neutral or false evaluations. Additionally, the study found that the purchasing rate is also higher under neutral evaluations than under false evaluations.

Kim et al.'s study highlights the importance of mental interactions and social cognition in shaping consumer perceptions and behavior. The study discovered that mental interactions and social cognition affect the association between authenticity and customer purchase intention. To put it another way, a product's consistency with a consumer's social identity and their favourable mental contact with it make the relationship between authenticity and buy intention stronger.

Both studies suggest that authenticity is a key factor that can influence consumer behavior and purchase decisions. Consumers tend to have more trust and confidence in products that are perceived as authentic, and this can lead to increased likelihood of purchase. The studies also highlight the importance of mental interactions and social cognition in shaping consumer perceptions and behavior.

Consumer Decision Making

The frontopolar areas of the brain, which are linked to the orbitofrontal cortex (OFC) and ventromedial prefrontal cortex (vmPFC) and are involved in determining subjective values, were found to be activated by positive purchasing decisions in the akir et al. (2018) study. The study also found that women are more likely to agree with the updated Construal Level (CL) theory than men are. This shows that the form of the CL theory that influences customers' decision-making depends on gender. However, the research on whether WOM (word-of-mouth) communication spreads specialised or general information during a product damage crisis is lacking, according to the study by Hsu and Cheng (2018).

Ratings

According to Kumar et al. (2019), EEG data can be analyzed using random forest-based regression methods to develop a rating prediction framework known as local rating. By incorporating both global and local ratings, the performance of the framework can be improved using an Artificial Bee Colony (ABC) optimization technique. In comparison to other unimodal rating prediction schemes, the study shows that this ABC optimization approach can produce a lower Root Mean Square Error (RMSE).

Shen et al. (2018) explored how aggregated ratings influence online purchase decisions by customers and the implications for businesses. The study also highlighted the potential for LPP (Late Positive Potential) components to be used as objective indicators of consumer behavior in academic and business settings. These components can provide insight into consumer categorization and emotional processing.

Tools Accuracy

Çakir et al. (2018) conducted a study that demonstrated the use of brain activations to interpret buying or passing decisions with 85% accuracy when sensitivity to the budget constraint was included as an extra element. The study used fNIRS, a new neuroimaging

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technique in consumer neuroscience. The results showed an improvement in accuracy over previous studies, with a decoding accuracy of 85%.
Muñoz-Leiva et al. (2018) undertook a study to assess the efficacy of promoting e-tourism technology using eye-tracking methodology. The results showed the benefits of this approach in assessing the promotion of these technologies.

Consumer Choice

Yadava et al. (2017) evaluated a proposed framework for predicting outcomes of choices using a dataset. The study employed a Hidden Markov Model (HMM) to calculate the outcomes using a user-independent training technique, meaning that the user's training data was not needed to anticipate their choice. The prediction outcomes were analyzed using leave-one-out cross validation.

The study investigated how rationally unregulated emotions can affect customer choices using an experimental design with observational measurement. The link between customer emotional responses and decision-making processes is illuminated by this design.

Attention

Studies have shown that attention renewal can occur when exposure to unexpected stimuli rejuvenates attention degradation. (Ahn et al., 2018). When users navigate search result webpages, their attention span shortens exponentially, and the rate and pattern of attention decline are greatly influenced by the number of options available. However, advertising cues can revive attention by diverting attention and categorizing search options into mental categories, reducing recurring attention decay patterns (Ahn et al., 2018). Advertising animation levels can moderate the impact of visit duration and fixation rates on consumer memory (Muñoz-Leiva et al., 2018). Placing a banner in specific areas on a webpage can result in higher recall, but the visitor's level of online experience and banner placement can also impact attention and recall (Muñoz-Leiva et al., 2021). In addition, new image-based qualities in visual communication are crucial for increasing engagement with digital visual content, according to other research that have demonstrated that appealing display design can increase target purchases (Karmarkar et al., 2021; Valentini et al., 2018). The findings also reveal that while female customers pay greater attention to brand names when a model has a straight look, male consumers are more drawn to models with direct gazes (Wang et al., 2020; Mo et al., 2021).

CONCLUSION

This study examined the recent 29 publications on the application of neuromarketing to e-commerce. The majority of the studies on this topic were released between 2017 and 2021, with the most studies being conducted in 2018. The findings also revealed that China, followed by Spain, had the most studies conducted in this area. Journals like Frontiers in Neuroscience, the European Journal of Marketing, and other journals in IT and neuroscience published the studies. The majority of the studies used EEG signals (41%) followed by Eye Tracking (25%) and fMRI signals (19%).

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The study by Casado-Aranda et al. (2019) on trust and consumer decision-making in online shopping contexts used functional neuroimaging to investigate the neural correlations between trust and different types of assurance in online shopping. The study found that seals of approval were the most effective in terms of activating brain regions associated with reward and expected values, while products with rating systems activated brain regions associated with uncertainty, pessimism, and risk. The study also found that consumer impulsiveness can significantly impact the assessment of online offers, with similar neural activation patterns seen in hedonic and prudent shoppers, also variations in the strength of patterns in brain regions connected to impulsivity and trust.

Another study by J. Wang et al. (2021) examined how dynamic visuals affected consumer intent to buy aquatic products. According to the research, dynamic visuals boosted purchase intention and decreased cognitive conflict in consumers, as shown by changes in N2 amplitudes and latency as well as an increase in LPP (late positive potential) amplitude. The study by Yen and Chiang (2020) also showed that a variety of factors, including trustworthiness, competency, anthropomorphism, social presence, and informativity, can affect how much consumers trust chatbots and their propensity to make purchases.

Research by Guerreiro et al. (2015) and Mo et. al. (2021) discovered that emotions are key factors in what consumers decide. Guerreiro et al.'s study found that physiological responses such as eye-tracking and skin conductance measurement are significant predictors of altruistic behavior in both hedonic and utilitarian situations. Mo et al.'s study found that contrast between clothing characteristics contributes to bottom-up visual attention bias, altering a person's emotional experience. Herrando et. al. (2022) found that physiological evaluations show that the observer's emotional arousal is consistent with that of the object of observation, and Qing et al. (2019) used EEG-based emotion detection to find that picture dynamism can elicit favorable feelings and enhance buy intention.

Studies by Qiu (2018) and Kim et al. (2021) found that authenticity plays a crucial role in consumer purchasing decisions. Qiu's study found that when a product is perceived as authentic, consumers are more likely to make a purchase, with a higher purchase rate in true evaluations compared to neutral or false evaluations. Kim et al.'s study found that authenticity positively impacts consumer purchase intention and that mental interactions and social cognition moderate this relationship.

In conclusion, these studies demonstrate the importance of trust, emotions, and product evaluation in consumer decision-making and the valuable insights that neuroimaging, physiological measures, and other techniques can provide into these processes. They indicate that seals of approval, dynamic images, and authenticity positively impact purchase intention, while impulsiveness, uncertainty, and picture dynamism can evoke negative emotions. These findings highlight the significance of considering trust, emotions, and product evaluation in marketing and online shopping strategies.

Recommendation

The following managerial recommendations for e-commerce companies can be offered in light of the results of the literature review:

1. Focus on building trust: Seal of approval, ratings, and other forms of assurance can help increase trust in online shopping. It is crucial to ensure that these trust-building measures are implemented and communicated effectively to customers.

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2. Use dynamic images: Dynamic images can increase purchase intention and evoke positive feelings in customers. E-commerce businesses should consider incorporating dynamic images in their product presentations and advertisements.
3. Emphasize product authenticity: Authenticity can significantly impact consumer purchasing decisions. E-commerce businesses should strive to maintain transparency and honesty in their product descriptions, labelling, and advertising to enhance product authenticity.
4. Address impulsiveness: Impulsivity can significantly influence customer decision-making, particularly when shopping online. E-commerce businesses should consider developing strategies to manage impulsive behavior, such as incorporating delay mechanisms or providing tools for consumers to control their impulse purchasing.
5. Consider emotions: Emotions play a critical role in consumer decision-making and can be evoked by different factors, such as contrast between clothing characteristics, picture dynamism, and more. E-commerce businesses should strive to evoke positive emotions in their customers and minimize negative emotions.
6. Utilize neuroimaging and physiological measures: Neuromarketing techniques such as EEG, eye-tracking, and fMRI can provide valuable insights into consumer decision-making and help e-commerce businesses to make informed decisions about their marketing and online shopping strategies.

Recommendations for the Future Research

1. Data analysis should concentrate more on making predictions by employing machine learning, which will lead to automation. Prediction and classification could add more to the analysis. In addition to traditional statistical methods, researchers could use neural networks, prediction, and classification algorithms. Only two out of all the research that used machine learning to analyze the data, it was discovered.
2. More neuromarketing studies are required to investigate Bu B2B, C2C, and B2B e-commerce as a whole and gain insightful knowledge about various forms of e-commerce. Only BtoC e-commerce has been studied; instead, BtoB, CtoC, and CtoB studies should also be done.
3. Future research should concentrate on recognizing complex emotions using tools from the neuroscience community rather than only positive and negative emotions. It is necessary to look at arousal, dominance, and valence more thoroughly. EDA, for instance, is a technology that may quantify emotional arousal.
4. Conduct further research: To better understand the effects of neuromarketing on e-commerce, more study is required in the rapidly expanding subject of e-commerce neuromarketing. E-commerce businesses should consider investing in research and development to stay ahead of the curve.

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