

## Neuromarketing: A Review of Research and Implications for Marketing

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### Abstract

In this research, we reviewed previous studies which adopted neuromarketing techniques in various fields of research. The results revealed that most of the studies in neuromarketing have focused on business applications. This research provides important results on the use of neuromarketing techniques, their limitations and implications for marketing research. We hope that this research will provide useful information about the neuromarketing techniques, their applications and help the researchers in conducting the research on neuromarketing with insight into the state-of-the-art of development methods.

Keywords: Neuromarketing, Literature Survey, Decision-making sciences, Consumer behavior

### 1. Introduction

The Consumer neuroscience is a newly developed burgeoning area consisting of academic studies at the intersection of marketing, neuroscience, economics, decision theory, and psychology (Morin, 2011). As an interdisciplinary and broad field of research, neuromarketing is defined as a tool which combines neuroscience and physiological techniques in order to get insights in customer behaviour for effective prediction of customer preferences in decision-making process (Yoon et al., 2006). Neuroscience can be used in marketing and consumer behavior research to refine existing marketing theories (Kenning & Linzmajer, 2011; Plassmann et al., 2015). Neuromarketing is one of the new fields of marketing that uses brain-imaging techniques to study brain responses to marketing stimuli. Researchers employ brain imaging to reveal why and how customers respond to triggers and what parts of their brains stimulate them to take an action. According to Chavaglia et al. (2011), neuromarketing is explained by the union of neuroscience

and marketing to find how the consumer really makes his online buying decision.

Several studies have been conducted for neuromarketing in various fields (Nilashi et al., 2020). The introduction of these studies according to the applied context and their outputs can provide researchers in neuroscience with insights into the state-of-the-art of development methods. Additionally, a comprehensive research should be conducted to demonstrate the usefulness of neuromarketing in conceptualizing consumer behavior and decision-making process. Compared to other domains, the application of neuromarketing technique is less matured and needs more investigation. Accordingly, this paper is trying to elaborate the importance and contributions of neuromarketing in various fields, especially in business context. We hope that this research will provide readers with an in-depth knowledge about the neuromarketing and its application in business research.

The rest of the paper is organised as follows. In Section 2, neuromarketing in customer decision-making is discussed. In Section 3, we provide an overview of previous research

papers on neuromarketing context. In Section 4, we provide the discussion. Finally, the conclusion and future work are presented in Section 5.

## 2. Neuromarketing in customer decision-making

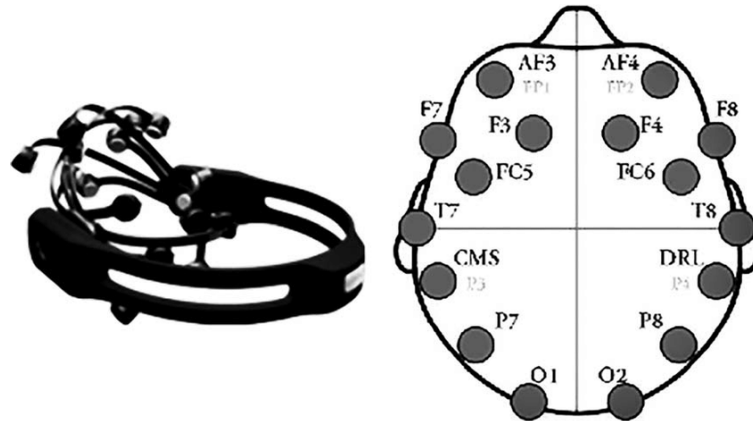
The analysis of customers' behaviour and detecting what influences their decision-making has gained researchers interest in many studies (Ahani, Nilashi, Ibrahim, Sanzogni, & Weaven, 2019; Ahani, Nilashi, Yadegaridehkordi, et al., 2019; Nilashi, Ahani, et al., 2019; Nilashi, Mardani, et al., 2019; Nilashi, Yadegaridehkordi, et al., 2019; Samad et al., 2020; Samad, Nilashi, & Ibrahim, 2019; Yadegaridehkordi et al., 2020). Extracting the knowledge from human brain is one of the important areas in company-specific market research. Several neuromarketing data collection tools are available to extract the behavioral information from customers which are magneto encephalography (MEG), Facial Recognition/Facial Coding System (FACS), Heart Rate (HR), electroencephalography (EEG), Galvanic Skin Response (GSR), Eye Tracking (ET), Positron Emission Tomography (PET), magnetoencephalography (MEG) and fMRI. According to Kable (2011), 60-70% of empirical neuroscience researches have applied only fMRI technique to collect the data from customers. Neuromarketing techniques are currently used effectively to improve marketing activities (Solnais et al. 2013). In Table 1, the adoption of three psychophysiological techniques in previous literature is presented. In practice, these techniques have been previously used in designing the look of food and beverages products, building design, as a sale advertising technique, and movies industrial. fMRI brain imaging technique has been investigated to find consumers' preferences regarding common beverage products (McClure et al., 2004). In addition, there are several well-known firms which are currently utilizing neuro-scientific techniques in their business which are: Yahoo, Google, McDonalds, Coca-Cola, Delta, Procter and Gamble, Carlsberg Beer, and ESPN, and they use this method for developing their advertisements in order to get customer attention (Burgos-Campero & Vargas-Hernandez, 2013).

Several studies have demonstrated that the use of neuromarketing can be used effectively in predicting consumer behaviours compared to traditional techniques. Some of the approaches that were applied previously in neuromarketing researches include: (1) steady state topology (Vecchiato et al., 2011), (2) fundamental magnetic resonance imaging (Breite & Rosen, 1999), (3) eye tracking approach (Popa et al., 2015), (4) electroencephalography (Morin, 2011), (5) galvanic skin response (Boz et al., 2017), (6) magnetoencephalography (Vecchiato et al., 2013), (7) respiratory monitoring (Lee et al., 2016), (8) heart rate monitoring (Mileti et al., 2016), and (9) trans cranial magnetic stimulation (Camus et al., 2009). A study by Berns & Moore (2012) showed the usefulness of fMRI in predicting the relative popularity of songs for improving purchase decisions. Venkatraman et al. (2015) used a unique protocol to evaluate consumer responses to TV ads. The authors used six methods: (1) fMRI, (2) traditional

self-reports, (3) implicit measures, (4) eye-tracking, (5) biometrics, and (6) electroencephalography to assess consumer responses to 30-second television ads and tested them through time-series data. In addition, traditional techniques in marketing cannot provide marketers with the sufficient information which can be obtained through neuromarketing techniques. Furthermore, the accuracy, usefulness and widespread use of conventional marketing research tools has been examined as a main concern of companies around the world for product marketing. Generally, fMRI is one of the most commonly used techniques for economic issues. fMRI involves the detection and visualization via MRI scanner, regional alterations in blood-oxygenation-level in the brain (known as BOLD signal) generated by neural activities. Additionally, EEG and MEG are widely employed as one of neuro-imaging methods. The two techniques probe brain activities at the scalp level through electrode and sensitive detector. As stated by Solnais et al. (2013), these 3 distinct technologies have various advantages and disadvantages (Table 2), which should be evaluated in terms of the study objectives.

Even though a number of neuromarketing firms employ fMRI that would be specifically acceptable for identification of anatomical structures in 3D and localization of brain activities, scholars doubt this strategy due to its highly cost and technical issues. Any person who will take a brain scan should be very motionless; that is, moving a head up to a few milli-metres more than 20 min may deviate data. Moreover, time works poorly with a lag of ~5 seconds between stimulus and observable activities of the brain. This condition causes difficulties in getting beneficial data of the cases such as TV adverts that discover a second-by-second basis. Therefore, a majority of neuromarketing relates to EEG that is a method with little technical challenges, which intrudes on brain activities through electrodes inserted on the scalp. In addition, EEG can be used easily and provides great benefits that overtake fMRI in terms of giving real-time information.

In previous neuromarketing studies, a series of instruments were used to collect data, including a brain signal monitoring system (i.e., Emotiv EPOC EEG wireless headset) (see Fig. 1) and an eye tracker system (Khushaba et al., 2013). Eye tracking is one of the sensor technologies, which provides the ground for a computer or other devices to capture where an individual is seeking. Presence, attention, and concentration of users may be detected by an eye tracker. Eye tracking provides certain knowledge of human behaviors and enables easier natural user interfaces in various instruments. Moreover, individuals who cannot speak or use their hands, may benefit from this capability by controlling the computer via the eyes. When data collected, each collected datum may be transmitted to a data analytical software; Matlab for example, for additional processing. This software is widely used by the researchers in different machine learning problems (Ahmadi and Nilashi, 2018; Ahmadi et al., 2019; Ahmadi, 2019; Nilashi et al., 2014; Nilashi et al., 2015; Nilashi et al., 2017; Nilashi et al., 2018; Nilashi et al., 2016).



**Fig. 1.** The use of EEG wireless headset in neuromarketing

**Table 1**  
The use of three psychophysiological techniques in marketing research.

Study	Marketing stimuli of interest	Psychophysiological technique		
		MEG	EEG	fMRI
Astolfi et al. (2008)	Advertising		√	
Cook et al. (2011)	Advertising		√	
Ambler et al. (2004)	Brands	√		
Ohme et al. (2009)	Advertising		√	
Santos et al. (2012)	Brands			√
Klucharev et al. (2008)	Advertising			√
Knutson et al. (2001)	Price			√
Reimann et al. (2010)	Packaging			√
Ambler et al. (2004)	Brands	√		
Young (2002)	Advertising		√	
Deppe et al. (2007)	Brands & Advertising			√
Deppe et al. (2005)	Brands			√
Deppe (2005)	Brands			√
Erk et al. (2002)	Products			√
Paulus and Frank (2003)	Advertising		√	
Rossiter and Silberstein (2001)	Advertising		√	
Levy et al. (2011)	Products			√
McClure et al. (2004)	Brands			√
Morris et al. (2009)	Advertising			√
Paulus and Frank (2003)	Brands			√
Plassmann et al. (2008)	Brands			√
Plassmann et al. (2007)	Products			√
Plassmann et al. (2008)	Price			√
Raab et al. (2011)	Price			√
Reimann et al. (2012)	Brands			√
Vecchiato et al. (2010)	Advertising		√	
Vecchiato et al. (2011)	Advertising		√	
Schaefer and Rotte (2007a)	Brands			√
Schaefer and Rotte (2007b)	Brands			√
Schaefer et al. (2006)	Brands			√
Stallen et al. (2010)	Advertising			√
Stoll et al. (2008)	Packaging			√
Yoon et al. (2006)	Advertising			√
Yadava et al. (2017)	Products		√	
Ma et al. (2007)	Products		√	
Vecchiato et al. (2012)	Advertising		√	
Bastiaansen et al. (2018)	Products		√	

**Table 2**

The neuroimaging techniques and their advantages and disadvantages (Solnais et al., 2013)

Neuroimaging Technique	How brain activity is measured	Technology	Advantages	Drawbacks
Functional magnetic resonance imaging	Detecting the changes in the oxygenation level of the blood	MRI scanner inside which the subject lies during the time of the experiment	– High spatial resolution (3 mm) – Measurements cover most brain regions, including deeper ones	– Relatively low temporal resolution (1–3 s) – High costs
Electro-encephalograph	Detecting the changes in the electric current in the form of brain waves	Electrodes spread on the subject's head (commonly 64 electrodes)	– High temporal resolution (in milliseconds) for the detection of brief changes in brain activity – Relatively low costs	– Low spatial resolution (around 1 cm, depending on the number of electrodes)
Magnetoencephalography	Detecting the changes in the magnetic field	Very sensitive detectors set on a helmet placed on the subject's head (more than 100 up to 300 detectors)	– High temporal resolution, comparable to EEG	– Low spatial resolution – Higher costs than EEG

Given the potential of cognitive neuroscience to transform the social sciences, we claim that information systems scholars can also advantage from by drawing upon the theories, methods, and tools offered by cognitive neuroscience. For instance, as technology adoption study gradually emphasizes on the automatic and characteristic behaviors that illustrate the adoption and post-adoption and use of IT tools (Asadi, Hussin et al. 2015, Asadi and Dahlan 2017, Asadi, Nilashi et al. 2017, Asadi, Hussin et al. 2018, Asadi, Abdullah et al. 2019, Asadi, Abdullah et al. 2019, Asadi, Nilashi et al. 2019, Dalvi-Esfahani, Alaedini et al. 2020, Samad, Asadi et al. 2020, Yadegaridehkordi, Nilashi et al. 2020), neuro-IS can enlarge the area of applicability for technology adoption theories beyond controlled conscious procedures to comprehend the essential role of automatic unconscious processes.

### 3. Overview of the research on neuromarketing

In the study by Yadava et al. (2017), the authors proposed a predictive modeling framework that examines EEG signals to reveal the consumer choice towards e-commerce products. They evaluated the method using various consumer products. They used user-independent testing approach along with Hidden Markov Model to record the accuracy of choice prediction. The proposed framework can be used effectively as a business model. Based on the semidirective interviews, Wannyn (2017) investigated academic challenges in a controversial research domain and demonstrated that discursive strategies have to be developed by neuromarketers to distance themselves from the controversial image of neuromarketing. Walter et al. (2005) provided an overview about the results of reward and social interaction neuroeconomics and discussed their relevance for economic behaviour. They also provided implications for neuromarketing as well as general implications of the obtained results to present deeper insights into the motives of the human behaviour.

Grimes (2006) examined the hemispheric lateralisation of brain function. The study provided a review of scientific research in the area and critically evaluated their application to marketing. Lee & Chamberlain (2007) conceptualized organizational cognitive neuroscience for human decisions, behaviors, and interactions and provided a brief overview of individual methods. They also discussed the possible convergence of different neuroimaging measurement modalities. Lee et al. (2007) made an attempt to provide implications for neuromarketing beyond consumer behaviours and commercial brands. They included a wide conceptualisation of marketing science and provided several future research directions. Ma et al. (2007) investigated the neural mechanism for the extension of a brand for a specific product category to other product categories.

Astolfi et al. (2008) investigated brain activities for TV commercials by the use of EEG recordings. The technique they investigated were effective for cortical networks and their behavior during the memorization of TV commercials. Ma et al. (2008) investigated the brand extension and the decision for the suitability of extending the brand. Wilson et al. (2008) examined the impact of neuroscience methods on marketing practices. Morris et al. (2009) investigated brain regions to validate pleasure, arousal, and dominance of emotion which have been induced by marketing communication. They used fMRI to identify corresponding patterns of brain activation. Guevara (2009) introduced the neuromarketing, its applications and brain-imaging techniques for neuromarketing.

Rapp et al. (2009) examined customer privacy issues and tensions between advertiser interests and consumer needs. Fisher et al. (2010) focused on the history of neuromarketing. The authors used an exploratory survey of neuromarketing web sites to investigate the ethical issues. Hubert (2010) investigated the neuroscientific methods and discussed the methodological problems in neuromarketing



area. Jain (2010) focused on advertising, food marketing and emotional effects of food and beverage products. Ma et al. (2010) conducted a research on the impact of negative emotion on brand extension. The research findings showed a negative impact of negative emotion on brand extension. Ohme et al. (2010) investigated the frontal cortex activation for TV advertisements. Reimann et al. (2010) performed four experiments for aesthetic experiences and investigated the psychological properties of package design. Stallen et al. (2010) used fMRI to investigate the influence of fame on product memory and purchase intention. Treleven-Hassard et al. (2010) conducted a research on the relationships of brands, interactive ads and automatic attention. Vecchiato et al. (2010) investigated the use of adequate statistical techniques in the neuroelectromagnetic brain mapping framework. They evaluated the work using a test data in a neuromarketing experiment. Dimoka et al. (2011) focused on cognitive neuroscience, e-commerce adoption using fMRI, and the role of functional brain imaging tools in the enhancement of IS theories. Kenning & Linzmajer (2011) focused on consumer policies and neuroethics and discussed consumer protection. Morin (2011) focused on the effectiveness of neuromarketing, commercial and cause-related advertising messages. Santos et al. (2011) designed a fMRI study for brand preference and decision process. Vecchiato et al. (2011) developed a study for commercial videoclips by analysing the changes in the EEG. Berns & Moore (2012) used neuroimaging to predict cultural popularity using fMRI. Berthoud (2012) focused on neuromarketing for modern food environment and hedonic, motivational and cognitive processing. Falk et al. (2012) focused on large-scale population behavior change and brain activations by recording smokers views while they are viewing television campaigns. Jones et al. (2012) investigated the consumer choices and purchase decision making by considering perceptual and conceptual processes in tracting with anxiety and gender. Lucchiari & Pravettoni (2012) investigated the impact of brand attachment on brain modulation. They used EEG modulation in their research. Plassmann et al. (2012) focused on consumer psychology of brands for the application of neuroscience to marketing. Reimann et al. (2012) conducted a research about actual brand choice using fMRI. Schneider & Woolgar (2012) conducted a research on neuromarketing for consumers' accounts of why they prefer certain products more than other products. Spranger (2011) investigated the imaging and legal consequences procedures in neuromarketing. Vecchiato et al. (2012) focused on the application of electrical neuroimaging and frequency patterns of EEG signals in neuromarketing. Wang et al. (2012) conducted a study on neuromarketing for brand extension with irrelative task. Angeles (2013) conducted a research on neuromarketing for attention to television, its theoretical models, and main developments. Javor et al. (2013) investigated the neurology and consumer neuroscience and indicated the compulsive buying as a common interest in this area. Khushaba et al. (2013) focused on physiological decision processes and customer

preferences of a product using EEG signals. Kong et al. (2013) investigated the impact of video commercials on consumers by impression index by the use of EEG. Lindell & Kidd (2013) focused on neuromarketing of educational products by the use of MRI brain image. They found a positive relationship between brain-based product names and consumer opinion. Pykett (2013) investigated the behavioural economics and piceoeconomics in neuroeconomics and provided a comprehensive review about the developments in economics. Sánchez-Porrás (2014) focused on marketing in audio-visual mass media in neuromarketing. Senior & Lee (2013) conducted a study on organizational cognitive neuroscience in the clinical practice. Thomas et al. (2013) conducted a research on social psychology for brand to test the relationship between non-name products and implicit positive attitudes. Wood & Ball (2013) studied the emergence of the 'brandscape' which combines the concept of the 'brand' with 'landscape'. Bruce et al. (2014) conducted a research about branding and advertising using fMRI. They found that food logos can activate some regions of brain in children. Koc & Boz (2014) proposed a new approach to consumer behaviour called psychoneurobiochemistry. Lee et al. (2014) focused on green consumers by the use of frontal theta brain waves of 19 right-handed respondents. Lin et al. (2014) focused on emotion classification and used machine-learning methods to explain the role of the EEG and music modalities in the emotion modeling. Mesly (2014) investigated the financial predator and prey's brain to understand the predatory core in human behavior. Pop et al. (2014) focused on neuromarketing technique in marketing research with and the ethical principles. Giovanni Vecchiato et al. (2014) focused on measuring emotions through the estimation of cerebral variables. They did some experiments using EEG, galvanic skin response (GSR) and heart rate (HR) in a group of healthy subjects. The main aim of their study was to overcome the drawbacks of previous standard marketing tools. Vecchiato et al. (2014) focused on cognitive and emotional changes of cerebral activity using of EEG, galvanic skin response (GSR), and heart rate (HR). Yılmaz et al. (2014) used EEG signals to detect indicators of preference (like or dislike decisions) of consumer products. Agarwal & Dutta (2015) studied the applications of neuroscience in addressing marketing and consumer behavior along with methodological concepts of neuromarketing. Añaños (2015) studied the customer behavior in terms of loyalty to television programmes. They collected the data from 30 elderly adults and 30 young adults. Bal'zhinimaeva (2015) investigated the influence of corporate criminal liability on reputation and image. Barré et al. (2015) provided a comprehensive review on brain imaging for non-medical applications to set a prospective framework for using brain imaging in product design. Boksem & Smidts (2015) investigated EEG measures (stated preference measures) and neural measures in the advertisements for commercially released movies. Christoforou et al. (2015) proposed a novel metric based on eye-gaze dispersion. They compared the proposed metric

with the Heart Rate Variability (HRV) indices. Escobar et al. (2015) focused on the combination of neuroscience and commercialization. They found that the use of neuromarketing is very promising to increase sales and profitability. Isabella et al. (2015) reviewed the neurophysiological methods and presented cultural studies in marketing to show the importance of using neurophysiological methods in different cultures. Lewinski (2015) found that specific patterns of facial expressions can predict the popularity of videos in YouTube. The author used a neuromarketing technique to code facial videos of professional speakers.

Sarrazin et al. (2015) investigated the issues raised by the application of the neuroimaging techniques in non-medical fields. Schneider & Woolgar (2015) conducted a study about the emergences of neurosciences and neuromarketing with their methodological difficulties, and concepts of multiplicity, performativity and practical ontology. Stoica et al. (2015) conducted a research on neuromarketing for the modern methods and tools for investigating consumer behavior. Ulman et al. (2015) introduced neurotechnology and investigated the ethical issues in this field. Varan et al. (2015) conducted a study on neuromarketing methods along with neuromarketers' measures of advertising effectiveness. Wang et al. (2015) used machine learning techniques to predict purchase decisions from spatio-temporal fMRI data. They selected 24 subjects and asked them to browse product images and to make decisions of whether to buy them or not. Al-Kwif (2016) focused on the factors that underpin consumer attitude toward switching a product brand using fMRI. Horska et al. (2016) used EEG equipment to reveal consumer preferences in different lighting conditions.

Bosshard et al. (2016) focused on consumers' attitudes towards established brands. They found that liked and disliked brands indeed has a positive relationship with affect-related valence. Chew et al. (2016) presented a preference-based measurement of user aesthetics using EEG signals for virtual 3D shapes with motion. They used KNN for classification task and achieved 80% of classification accuracy. Crespo-Pereira et al. (2016) investigated the impact of neuromarketing in its application to the Spanish audiovisual sector. Daugherty et al. (2016) focused on consumer neuroscience, neuromarketing technique, and dense-array EEG. Fan & Touyama (2016) studied the emotional face retrieval and proposed emotional face retrieval using P300 signals of 20 subjects. Fudali-Czyz et al. (2016) investigated event-related potentials for the process of brand extension evaluation. Their experiments were on a beverage brand name and a product name.

Gupta et al. (2016) investigated the use of EEG graph-theoretic analysis for characterizing the ratings. They used graph-theoretic features for the classification of emotional states with the aid of two classifiers, support vector machine (SVM) and relevance vector machine (RVM). Horska et al. (2016) conducted a research on neuromarketing and analysing facial expressions by the use of EEG for eight kinds of blank samples of wine. Kim et al.

(2016) conducted a study to find the impact of oxy-haemoglobin (Oxy-Hb) concentrating on customers' preference using a 16-channel NIR spectroscopy system. Kühn et al. (2016) conducted a study to forecast consumer behaviour in a supermarket using fMRI.

Lee (2016) investigated the emotional mechanism of empathy using EEG for the customer equity and willingness to pay. Mileti et al. (2016) conducted a research on neuromarketing and discussed the limitations and opportunities. Morillo et al. (2016) proposed a new approach in the area of marketing research to show how brain activity responds when visualizing short video advertisements using EEG. Priilaid & Horwitz (2016) investigated how the price can moderate assessments of coffee quality across profiles of gender and experience. Shen & Morris (2016) proposed an integrative procedure by the combination of a visual self-reporting scale and fMRI to measure emotional response to television commercials. Wang et al. (2016) studied the impact of advertising narrative by the use of EEG on 30 subjects after watching the commercial videos.

Wolfe et al. (2016) studied differences in brain activity among familiar and unfamiliar foods using fMRI. Zhao & Siau (2016) reviewed the cognitive neuroscience and fMRI, PET, EEG, MEG, and eye tracking, and explored the strengths and weaknesses of these tools. Bakardjieva & Kimmel (2017) conducted a study on neuromarketing for the role of personal constructs presumed and attitudes, ethics, and behavioral intentions. Baraybar-Fernández et al. (2017) studied the impact of emotions on the memory of the subjects. They used electrical activity of the heart and electrodermal activity of the subjects. Boz et al. (2017) studied the impact of price of a touristic product or service on psychological influences on the customer by providing neuromarketing examples. Cartocci et al. (2017) presented a study on advertising perception by the use of EEG, Heart Rate, and Galvanic Skin Response Assessment signal analysis. Christoforou et al. (2017) presented a computational approach to predict box-office performance from viewer's brain Responses to movie trailers. Crespo (2017) provided a study for the applications of neuroscience in the political science and the role of emotions in the behavior of voters.

Crespo-Pereira & Legerén-Lago (2017) conducted a bibliographic review of the design of audiovisual content through the applications of neuroscience. They provided several recommendations of the effective design of TV content. Crespo-Pereira et al. (2017) conducted a study on audiovisual neuromarketing. They used an exploratory analysis and in-depth interviews in their study from academics, professionals, neuroscientific experts, and neuromarketing consultants. Cuesta-Cambra et al. (2017) used Eye Tracking and EEG signals for the purpose of cognitive processing of an educational app. Fehse et al. (2017) used fMRI for revealing the consumer behavior towards food brands. Fidelis et al. (2017) conducted a study about sexual appeal in print media advertising by investigating the influences of brand recall and fixation time. Fidelis et al. (2017) developed a new method and

used EEG signals in their experiments. The classification accuracy of their method was around 80%.

Goto et al. (2017) conducted a research about subjective preferences and buying decisions in a virtual shopping task. They used event-related potentials method for the data analysis. Grigaliūnaitė & Pilelienė (2017) conducted a research on neuromarketing and examined the impact of negative smoking-related pictures on implicit and explicit attitude toward smoking. Guixeres et al. (2017) conducted a research on consumer neuroscience-based metrics to predict recall, liking and viewing rates in online advertising. They found that neuromarketing-based techniques are effective in predicting the success of advertising responses.

Hamelin et al. (2017) examined the effectiveness of emotions and advertising by developing a novel facial expression analysis approach. Hensel et al. (2017) developed a study for conducting neuromarketing studies ethically. They collected the data from 10 neuromarketing practitioners and found five additional ethical aspects that should be considered in neuromarketing research. Kahn (2017) investigated the visual design to enhance consumer perceptions of online assortments. Lee et al. (2017) conducted a comprehensive review on neuromarketing. The authors provided several points for the development of a more reflective neuromarketing. Lopes et al. (2017) proposed a solution for facial expression recognition with convolutional neural networks. The method accuracy was 96.76% in the CK+ database. Lobato & Garza (2017) developed a classification algorithm to measure the human emotion: "do like" and what we "don't like" by the use of EEG. Missaglia et al. (2017) investigated the impact of emotions on recall for social advertising. Pileliene & Grigaliunaite (2017) developed a neuromarketing approach to reveal the effect of female celebrity spokesperson in FMCG advertising. Ramsøy et al. (2017) conducted a research about the assessment of consumer preference and choices by body posture and pupil dilation.

Salati & Leoni (2017) showed that the use of neuroscience can significantly improve the efficiency of companies. The authors carried out some experiments by the Training Department of a large public transport company. Shigaki et al. (2017) conducted a study on consumer neuroscience and neuromarketing topics and provided analysis of adopted methods, the applications of these methods, and the contributions to the marketing field. Stanton et al. (2017) presented a study about the ethical issues in neuromarketing research practices in industry. The authors identified the steps to alleviate associated ethical risks and accordingly to reduce the threats to consumers. Tichý et al. (2017) conducted a study about the use of neuromarketing eye-tracking methods for the verification of the efficiency of food styling. Touchette & Lee (2017) measured the neural responses to apparel product attractiveness by the use of frontal asymmetry theory. Yadava et al. (2017) conducted a study on the analysis of EEG signals and the application of the EEG signals analysis to neuromarketing to understand consumer choice towards e-commerce

products. In this study, they used Hidden Markov Model and conducted the data analysis using EEG signals.

Avinash et al. (2018) demonstrated Frontal Theta Asymmetry while listening to music for 41 individuals. From this work, it is obvious that positive emotions boost the theta power which is located in the left side of the hemisphere and negative emotions boost this power on the other side. Furthermore, multifarious approaches related to EEG used for neuromarketing. Also, for diminishing the two important factors (computational time and complexity) and assessing the emotion status, the authors utilized EVI and electrodes models. The statistical experiments like K-NN, LDA K-NN carried out and they got high accuracy rates in their work. The work presented by Bastiaansen et al. (2018) proposed a new neuromarketing method in order to create a brain event-related potentials (ERPs) for assessing the efficiency of the tourist marketing destination in movies. The Images of the individuals from Bruges and Kyoto cities were taken, before showing the images, the first category watched an extract (In Bruges) from the movie that showed the tourist attractions of this city. Regarding other categories, they watched an extract movie (The Rum Diary) which did not have the characteristics of this city. Therefore, the emotionally reaction was just obtained to the following represented Bruges images for this (In Bruges) category and there was no sign of reliability between category distinctions in ERPs to images from Kyoto. Lim (2018) explained how the method related to mixed information inquiry and the analysis of the contents and themes can make contribution for neuromarketing future which plays as motivations for improving the science of the marketing. Stasi et al. (2018)), produced a review paper regarding food selection by neuromarketing methodologies and they depicted the methods, hypothesis, and the benefits of that in this issue. Moreover, they concentrated on non-invasive approaches for proposing the most successfully improvements to carry out this new technique in the area of food marketing. In the paper which published by Lewandowska et al. (2018), the productivity of various variants of the labels in the life cycle based to the surrounding knowledge was surveyed. According to this study, all the information related to eye tracking, the neurologically reactions, the data related to the buyer ecological consciousness, and electroencephalography is collected and utilized for recognizing the items that are ecoleable with the most strong communication ability. This goal is not restricted for the environmental labelling expertise's; the green marketers and the practitioners in the domain of life cycle estimation and environmental footprint can be involved.

Overall, the distribution of neuromarketing techniques applied in different fields is shown in Fig. 2. From Fig. 2, we can see that the majority of publications (23.39%) in neuromarketing has been for Business Economics, followed by Psychology, eurosciences Neurology and Social Sciences.



#### 4. Discussion

Neuromarketing can be considered as a profitable marketing approach for businesses that practice neurobiology to marketing research, observing customers' nerves, mental, and actual reply to marketing incentives. Marketing scholars, marketing managers, and brand managers use neuromarketing to evaluate customers' preference towards different products/services or brands. Neuromarketing can explain precisely why customers make shopping decisions. Hence, because of the significant impact of neuromarketing on brands, neuromarketing quickly has been recognized as a perfect technique which links the theory to practical business issues. In addition, neuromarketing has brought multifarious benefits for marketers, not only due to the consideration of psychological and sociological aspects, but also because of the cognitive aspect of using the technique. It can assist in recognizing the patterns of the brand recollection from customers by watching the advertisements with and without social messages. The information delivered by neuromarketing will aid businesses to deliver the products/services more efficiently. Furthermore, the marketing campaigns can be emphasised more on the mind of their shoppers by selecting proper advertising or marketing strategies. Therefore, neuroscience provides us this opportunity to research more about every category and divide the market into larger abstract foundations. Obviously, the approaches that are based on neuro-science would give data related to the growth of trust. For a better understanding of neuromarketing, this research delivers an overview regarding the wide range of neuromarketing techniques and their applications in different research areas. The results of our research showed that the majority of neuromarketing studies have been published in business journals. Indeed, the use of neuroscientific methods in marketing research has gained substantial interest, which leads to a growing number of journals and review papers in this field. But, there is a critical problem regarding the lack of directions regarding neuromarketing data analysis. Therefore, neuromarketing studies need more collaboration among scholars from miscellaneous fields of research, such as marketing, psychology, and neuroscience. In addition, the neuroscience findings are critical to disclose the consumer behavior procedures for developing the philosophy of neuromarketing increasing significant meaning to the field of neuromarketing research. Accordingly, more literature resources in top marketing journals can be published to advance the development of neuromarketing research. For instance, neuromarketing studies continue to observe the impact of physical sympathy on the behavior of the buyers, customer's decision-making, shoppers' health, and the general involvement in consumption process. Thus, the neuromarketing outcomes should be described through the collaboration of researchers by considering the complication of the trial, the nature of the stimuli, and the related neuroscience standards.

The combination of market research, consumer neuroscience, and financial psychology through the

collaboration of multidisciplinary scholars will play a significant role in developing neuromarketing. This research presented the relevance and suitability of each of neuroscientific techniques, providing a brief explanation about the attributes for neuromarketing researchers. The applied psychological or biometric measures in neuromarketing include facial expressions, electrodermal activity, eye tracking, respiration, heart rate, and response time. One of the conventional methods that has been performed in marketing domains is fMRI and it has been used in most current researches and academic areas. fMRI, as the most applicable technique, is balanced by the advantages of complementary and cost-effective tools such as EEG, eye tracking, and implicit measures. One of the probable drawbacks of the current neuromarketing studies is that they are mainly based on fMRI technology that is costly and demands cases for dressing in a hospital gown, lay on a narrow table, and wear earplugs when the stimulus is displayed via a projection headset. Participants may just interplay with stimuli via pressing 1 of 2 buttons, so that one of the buttons are held in each hand. Moreover, fMRI suffers from a partly weak temporal resolution. Nonetheless, EEG involves a more accessible option to do neuromarketing studies. EEG recording system can be commonly provided. In addition, costs of purchase and operation of the system are merely a fraction from the costs of the fMRI systems. Moreover, EEG provides the ground for participants for sitting and viewing stimuli in a comparatively natural way while recording reactions in the brain at a very high (milli-second) temporal resolution. In fact, mental actions are recorded by EEG at the moments they are occurring. One of the disadvantages of EEG is that it cannot provide a 3D view within the brain, and just records views from its surface. Such as situation causes problems for relating the recorded signals directly to the neural activities in certain brain structures. One of the other drawbacks of EEG is that ERP regulations, which relate to positive and negative emotions, have high similarity that requires further documents to qualify emotional responses, which can be associated with either positive or negative emotional values. Nevertheless, the comparatively natural context of EEG and the respective additional duration resolution results in its usefulness for neuromarketing research.

Neuromarketing trials usually must be directed in the special laboratory as it is not easy to mimic real-life circumstances, and to avoid any external disturbance that presents in real-life. Therefore, this has consequences in verifying the experimental results especially, when you want to apply these things in real world. Generally, the scholars believe that it is the combined use of dissimilar approaches surrounded by customer research that is vital for understanding the diverse modules of the consumer's behavior. Only a single neuroimaging technology, such as fMRI, can be applied at moment. This leads to an incomplete understanding of the relationships among multifarious physiological processes and behaviors. Therefore, non-invasive methods of neuromarketing such as psychological instruments (e.g., eye tracking, galvanic



skin response) and brain imaging instruments (e.g., fMRI, EEG) provide a promising insights to dynamically observe brain activities through the implementation of definite duties, which offers businesses with a deep understanding of their customers. Furthermore, while scholars provide a complete theoretical argument of the neuromarketing issue, empirical researchers should take into account the reverse implication difficulty more strongly. The recommendation

for future studies is using the methods supported by previous academics which generate big-scale automated meta-analytic maps of mind activation. While such approaches cannot completely resolve the difficulties, they can deliver scholars with more approved methods to prevent coherent faults of implication and get more acceptable results.

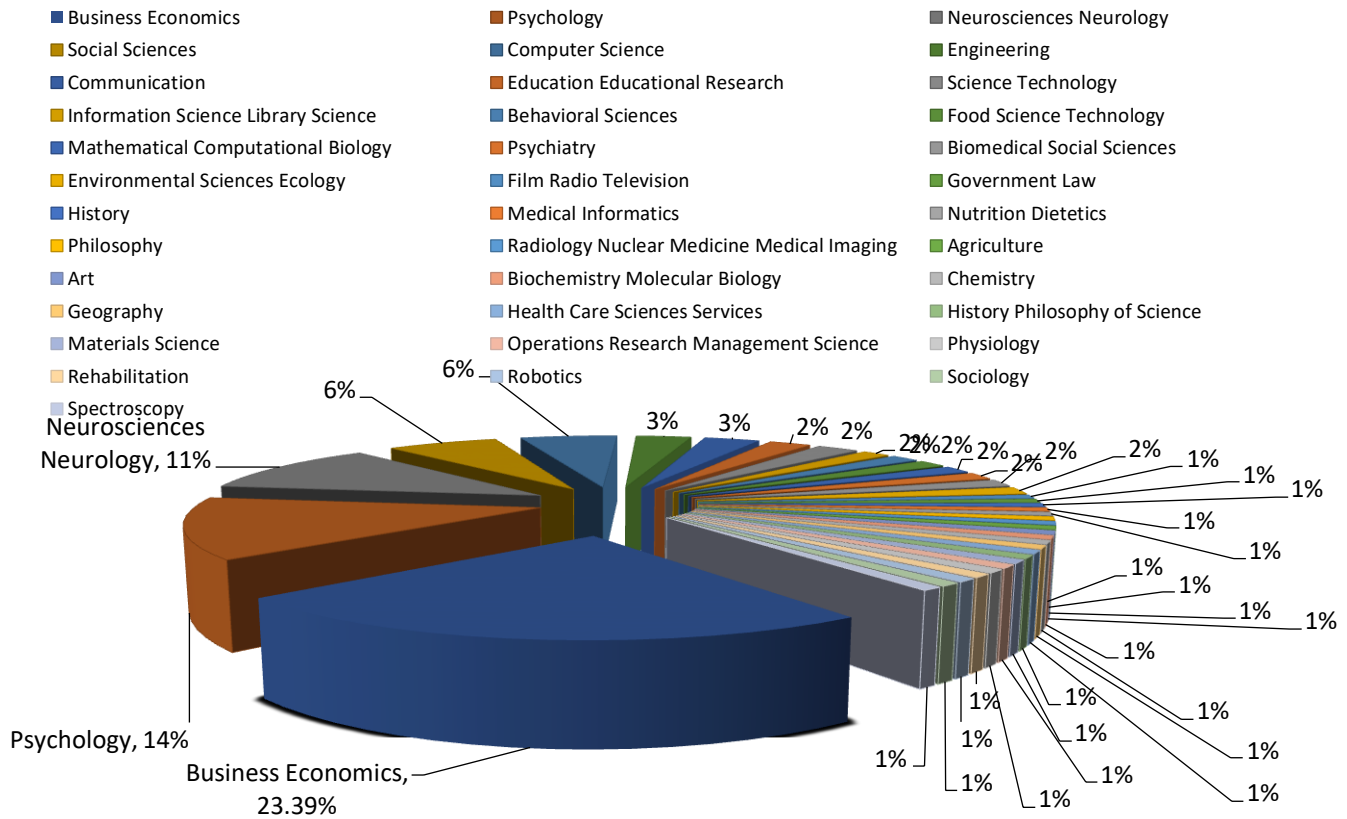


Fig. 2. Application of neuromarketing technique in different contexts

Moreover, the ethical features should be taken into account through the investigation of neuromarketing studies. One of the biggest concerns in neuromarketing studies is the ethical issues. Ethical worries are deliberated as one of the most significant concerns of neuromarketing researches among marketing scholars, marketing experts, and neuroscientist. The first ethical issue from the customer’s point of view regarding neuromarketing is the price. Because the required tools for neuromarketing studies and the nature of the study is expensive and time-consuming. Hence, customers should pay more money for the product/service because of the cost of neuromarketing research. The second ethical issue is related to the fact that neuromarketing researchers penetrate to the consumers’ opinion. For instance, when asking the respondents personal questions, they might refuse to answer. However, during brain testing, this cannot be performed. Unsuitably, researchers receive more data from the test compared to the one necessary for the study purposes. Ethical problems should be specifically attended because scholars may gain

this information during research, which are not part of the study and can result in violating privacy. Several researchers claim that data received by neuromarketing must be neglected, and it is necessary to prohibit the application of marketing campaigns. Another problem might be the feeding consumption of the products/services. For example, a neuromarketing experiment can exam prospective advertisements to realize which schemes have the anticipated impacts on purchasing. This experiment can be ethically acceptable if the only effect is for the customers that select one similarly goods or superior product rather than alternative ones. On the other hand, more influential ads can be damaging if they make new requirements for the product/service that are less important or that the customers do not actually need. Unprecedented level of manipulation by the companies in their marketing purposes has been one of the ethical critiques of neuromarketing. This critique is based on the idea that consumers may be unfairly affected through the use of specific stimuli and leads to particular physiological replies

which cannot be discovered unless through neuromarketing research. The development of this field of behavioral sciences can make a win-win condition for the businesses and the customers at the same period. The businesses can get interior information that leads to a better product/service/brand marketing and the buyers have more customized goods/services. Additional challenging about neuromarketing is related to the human rights as neuromarketing research sometimes cannot be confirmed by related authorities to certify ethical behaviour of study. Moreover, companies that conduct behavioral research without ethical approval have been regarded as a topic of argument and have remained to be debatable even between scholars in other field of research. Upcoming research could emphasis on amending and standardizing the ethical neuromarketing customer-centric approach by considering the consumer neuroscience and neuro ethics principles. One way to undertake some neuromarketing issues is using nanotechnologies that introduce an innovative prospect for neuromarketing research. The nano marketing which is the integration of neuro marketing and nanotechnologies can be considered as a new field of research.

## 5. Conclusion

This research investigated the applications of neuromarketing in different research disciplines. We have reviewed previous research papers which used neuromarketing techniques. The results from this research showed that the majority of the selected papers have used neuromarketing techniques in conducting researches in business context. This study has several limitations. First, this research didn't focus on the use of neuromarketing tools in obtaining the data form users for information extraction. In-depth analysis on these tools can be performed in future studies. Second, this research has introduced the neuromarketing taxonomy from the previous studies. The taxonomy can still be updated from the new research on neuromarketing. Accordingly, we will continue our research in the future to classify research papers on an ongoing basis and based on the limitations of this research. We hope that this research will provide useful information about the neuromarketing techniques, their applications and help researchers in developing neuromarketing techniques with insight into the state-of-the-art of development methods.

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