Review of neuroscience in marketing: areas, emotions and tools

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Abstract: Little work has been done to bring these various studies together to offer a solid building block on which theory can be further developed in a rigorous manner. We address this gap by conducting a multidisciplinary literature review to provide a unified understanding of research that has been conducted within neuromarketing. Articles related to neuroscience in the past 20 years (1997–2016) were downloaded from EBSCO using relevant keywords. Contribution wise, first, we provide a unified perspective of the research that's been conducted within this field. Second, we identify future research opportunities within neuromarketing, such as the tools that can be employed, specific areas where the tools can be applied, and specific emotions that can be investigated. Third, we provide additional guidance by discussing strengths and drawbacks associated with these various approaches. This article segregates past research in three unique buckets: tools, areas in marketing and emotions.

Keywords: neuromarketing; neuroscience; marketing; consumer; advertising; fMRI.

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1 Introduction

Psychology impacts consumer behaviour, one of the antecedent states being emotions (Belk, 1975). They not only play a big role in behaviour of a consumer, but also a reason behind various strategies used in marketing, including branding, advertising, sales, etc. Unfortunately, it is one such aspect of consumer, which is unpredictable and difficult to research on, without being equipped with certain tools. Fortunately, recent years have provided researchers with equipment like neuro-marketing, which can help measure these unpredictable thoughts and actions of a consumer.

Neuromarketing is an estimated two billion-dollar industry as of 2014 with a growing number of firms attempting to explore a consumer's brain (Cerf, 2014). The potential insights that neuroscience can provide are difficult to ignore. Procedures such as single-neuron electrophysiology allows researchers to successfully eavesdrop on the activity of individual brain cells. With this procedure, researchers can study patients and identify "cells in their brain that tell us that they are about to press a button, move a cursor, or say something sometimes seconds before they actually act on their will, or are aware of it" [Cerf, (2014), p.4].

As such, it comes as no surprise that large corporations such as PepsiCo, Intel, ESPN, and eBay are taking advantage of neuromarketing in creating their advertising strategies. As one industry executive described "we can say goodbye to those endless expensive bloody research groups where consumer either lie their head off or tell us what they think we want to hear" [Walton, (2004), p.22]. For example, PepsiCo's Frito-Lay division used Neuro-Focus to test women's responses to Baked Lays which helped develop an ad campaign and new single-serve packaging. Similarly, Neuro-Focus helped ESPN make its sponsor splashes more noteworthy and helped eBay's PayPal division find a more refined corporate identity than "safe, simple, wow!" (Perry, 2014).

Marketing researchers have recognised the benefits of neuroscience as evidenced by the growing literature in this area (Fugate, 2008; Khushaba et al., 2013; Meckl-Sloan, 2015) with exponential rise in number of articles from zero in 1997 to approximately eighty articles in 2017, with just the word 'neuromarketing'. Neuromarketing has revealed significant new information about human preferences and emotional responses when customers view and evaluate different advertisements (Suomala et al., 2012). Despite the call for additional research, the field is still in its infancy (Vecchiato et al., 2011). Disparate studies have been conducted, but little work has been done to bring

these various studies together to offer a building block on which technique can be further developed in a rigorous manner.

The authors address this gap by conducting a literature review to provide a unified understanding of what type of research has been conducted within neuromarketing compared to other fields as well as fruitful avenues for future research. Specifically, they explore the areas of marketing (advertising, branding etc.), the range of emotions that can be examined using nueromarketing along with providing a better understanding of tools available to marketing scholars. The authors respond to the call of researchers for a multidisciplinary approach to neuroscience to uncover the unprecedented research opportunities available (Yoon et al., 2012). At the same time, they provide an insightful, critical perspective on the benefits and challenges associated with each tool to provide additional guidance to marketing scholars in their choice of method. The rest of this manuscript is organised as follows: starting with a discussion of the methodology employed to execute this research followed by conducting a comprehensive systematic literature review and ending with conclusion associated with the study.

2 Methodology

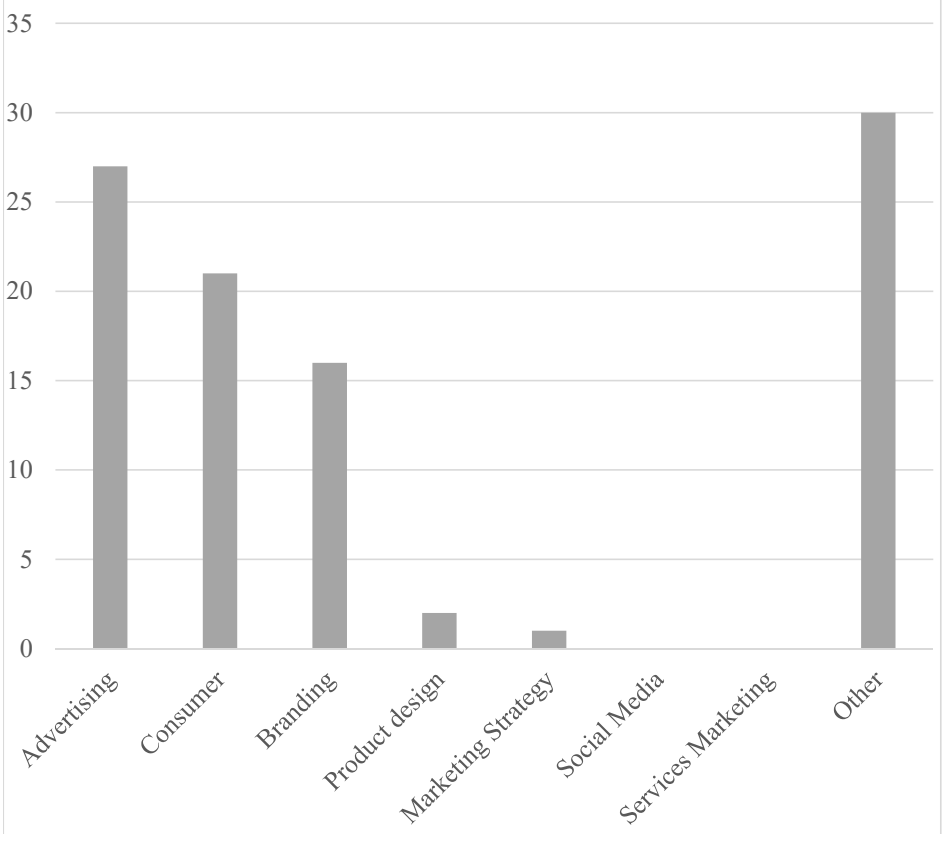
To ensure an unbiased and valid evaluation, the guidelines for systematic literature review were followed (Denyer and Tranfield, 2009; Rousseau et al., 2008). An exhaustive search of the current body of literature on neuroscience, neuromarketing and various brain scanning software used across various disciplines was conducted, beginning with the EBSCO database (Gligor and Holcomb, 2012), PsycINFO and PsycARTICLES: collection of psychology related articles as well as PUBMED, known for its abstract collection in medical field. Key search terms (and variations thereof) for each of the areas of interest were used to examine peer reviewed journal articles published from 1997 through 2019. Thus, the major filter criteria were: year and keywords – ‘neuroscience’, ‘neuromarketing’, ‘brain’, ‘fMRI’, ‘neuro’ and ‘neuro-science’. Marketing as well as non-marketing articles were considered, if relevant. Similarly, keywords used to look for articles in neuromarketing included ‘neuro-marketing’, ‘neuro’, ‘advertising’ and ‘brain’. When looking for articles in the database, it is expected that not all journals or articles related to the keywords appear in the search list. To address this issue, the authors not only read the articles which appeared in the list, but also looked for references and citations mentioned in the listed articles. This process continued until the authors reached a point wherein no additional articles could be found (Gligor and Holcomb, 2012). A total of about 250 papers were assembled and assessed as per the procedure mentioned above. Each article was reviewed to identify various tools used to measure the brain activity as well as the emotions that were captured using those tools. The authors focus their attention on three distinct aspects as they pertain to marketing research: areas (e.g., advertising) where neuroscience has been utilised; emotions (e.g., fear) assessed using neuro science; tools used within neuroscience, discussing their advantages and disadvantages.

2.1 Areas studied under neuromarketing

Practitioners and researchers have focused on understanding consumer behaviour by examining subjects’ brain activities, facial expression, and eye movements. Areas like

advertising effectiveness, brand evaluation, new product design as well as sales performance have been investigated using neuroscientific tools. The following section attempts to focus on various areas in marketing where these tools have been used (past research) and the areas which have been scantly researched on (future research).

Figure 1 Percentage of articles published in each area (see online version for colours)



2.1.1 Past research

This subsection includes the areas (advertising, branding, product design, sales performance and consumer behaviour) within marketing wherein; neuroscience has already been used to understand consumers' minds.

1 *Advertising*: Every year, over 400 billion dollars are spent on advertising campaigns worldwide, but traditional methods of testing or measuring the effectiveness of commercials or advertising fail because these methods depend on consumers' willingness and competency to explain what and how they feel when they are exposed to such stimuli (Morin, 2011). In recent years, however, researchers have started to benefit from neuroimaging tools, neurophysiological measures and similar techniques to measure conscious and unconscious behaviours of consumers in different types of commercial advertising. Considerable research has used these instruments to gauge customer's reactions to advertising stimuli and better

understand brand preferences (Murugappan et al., 2014), advertising effectiveness (Ohme et al., 2009) customer attention to advertising and visual activity of consumers (Siefert et al., 2008) and cognitive and emotional responses to advertising stimuli (Dimpfel, 2015). For example, Siefert et al. (2008) used an eye-tracking method to track viewers' eye patterns on real time adverting and on fast forward (FF) in DVR. Additionally, Ohme et al. (2009) conducted a study concerning the analysis of skin-care products advertisement presented in two slightly different ways by using EEG, electromyography (EMG), and skin conductance (SC). The results indicated that even if the ads were almost identical, the impact of these ads regarding product benefits, key benefits, and behavioural tests are significantly different. This study presents evidence that advertising managers can benefit from EEG research as it can provide meaningful empirical evidence of particular emotional responses to advertising stimuli. All in all, the authors, encourage the advertising researchers to not only use such techniques to understand a consumer's mind, but also use multiple tools at a time to validate and further dig into the details of their brain activities.

2 *Branding*: Neuroscientific instruments have been used to monitor participants' brain activity to see whether different regions of a subject's brain light up when the subject is exposed to a familiar or unfamiliar brand. The majority of articles that were collected for the purpose of this literature review, used EEG and fMRI to test customers' brain activity responding to known and unknown brands (for example, see Santos et al., 2012). These studies show that while the subjects are exposed to familiar brands, the frontal cortex activates, implying the self-knowledge, person perception and metalising (Amodio and Frith, 2006). On the other hand, unknown brands resulted in activation in the orbital frontal cortex, which is responsible for monitoring outcomes (Amodio and Frith, 2006). The face-recorder software was used to understand the participants' emotional reactions (sadness, happiness, anger, and other negative and positive emotions) when they are presented with a brand in a commercial. This study shows that companies can gain competitive advantages by using neuroscientific tools that help gain insight into how customers feel when they see brands (Neto and Filipe, 2016). Although fMRI and EEG have been used, other tools which are mentioned in the tools section can be used to identify brand related activities. For example, SST can be utilised in future studies to test brand communication (Bercea, 2012). Past studies show that neuroimaging instruments can be applied to understand physiological responses to brand positioning, brand relationship, brand enhancement efforts, brand communication and other related brand efforts because researchers can monitor which parts of the brain is activated, and what types of emotional responses they give when they see the brand. Thus, the authors encourage future neuromarketing researchers to try hands on other tools like TMS and PET to understand the impact of branding on a consumer from a different perspective.

3 *Product design*: Companies such as Hyundai Motor and Cheetos have used neuroscientific devices to develop their products. For example, Hyundai utilised EEG-test during their car design processes to gauge customer reactions when participants are looking at a particular part of the car (Kumar and Singh, 2015). Frito-lay used to design the packages of potato chips with bright-coloured packaging which activated frontal cingulated cortex, which is associated with the feeling of guilt. They replaced this package with a new design that is related to health (Kumar

and Singh, 2015). In addition to these practical evidence, empirical studies also provide valuable information regarding customers' responses to different types of product and package design. For instance, Reimann et al. (2010) studied the aesthetic package design by applying fMRI. The results show that aesthetic packaging significantly improves the reaction time of customer choice, which is associated with the well-known brand in the standardised packages.

Another study investigated the response of subjects to various cracker types based on flavour (wheat, dark rye, plain), topping (salt, poppy, no topping) and shape (square, triangle, round) by using EEG and eye-tracking methods. The results show that significant changes happened in the occipital, temporal and frontal regions of the brain when subjects indicated their preferences. Also, the study shows that when customers make a purchase decision, they are looking at topping and flavour more than shape (Khushaba et al., 2013). Overall, a lot of studies have looked into the packaging perspective of product design, specifically for food packaging as well as menu labelling (Gala et al., 2018). It would be interesting to understand the consumer's thoughts when it comes to size, shape and colour of the product. Also, different types of products like cell phones, apparels and other electronics, which make up for huge retail market should also be studied with the help of neuromarketing.

4 *Consumer behaviour*: Behaviour of a consumer is unpredictable. Considerable research has been conducted to understand what factors impact customer decision-making processes, what stimuli entices them to purchase goods or services, and what emotions have triggered their feelings to concentrate on a particular type of advertisement. Berčík et al. (2015) conducted a study of measuring the effect of light and colour on the emotions of customers on the food market by using EEG with 67 younger and older volunteers in a laboratory environment. The authors investigated the impact of the integration of different colour of lighting, temperature, colour, and light intensity in the grocery store on customer emotional responses and response time. The result revealed that customers' feelings differ depending on the type of accent light used. The article suggests that retailers can create an eye-catching and attractive presentation of their product and make savings in their stores with the right integration of the efficiency, energy intensity and visual impact of accent lighting by using neuroimaging tools.

The customer decision process is influenced by other factors such as music playing in the background. Berčík et al. (2016) explored whether or not playing music (e.g., French playing slow, Slovak playing fast or nothing) in merchandising good store impact customer perception and emotions when they are choosing food by using EEG and eye camera in a laboratory environment. Heat map results obtained from eye-camera reveal that when wine bottles are placed separately, participants pay more attention to it. If the product is noteworthy, it can be set individually to catch customers' attention. The authors can see that customers' decisions are affected by their emotions, feelings or other related stimuli. Studies show that companies can better understand their customer behaviour by using modern scientific tools because customers' behaviours are impacted by emotions and feelings that may not be recognised at the conscious level.

2.1.2 Future research

From 1997 to 2016, the majority of research collected applied neuroscientific methods to advertising development, advertising effectiveness, brand relationship/brand evaluation, sales performance, product design, and ethics. In this subsection, the authors aim to discuss the possibility of using neuroscientific and biometric tools in areas where they have been rarely, if ever, employed, like social media, strategy and services marketing.

2.1.2.1 Social media marketing

Social media is a growing phenomenon that allows individuals and communities to create and share content via two-way communication (Davis et al., 2012). These media platforms have encouraged two-way communication between customers and companies (Rapp et al., 2013). Undoubtedly, the considerable numbers of social media users have motivated companies to interact with customers. Companies create content to gain customers' attention, but they sometimes fail because of unrealised poor or unattractive content creation.

The authors suggest using neuromarketing techniques to create engaging content. For example, eye-tracking method can be used to check where users first look, at what content, on which part do they focus more, their blink rate speed, and their excitement (Bercea, 2012). If customers look at a particular part of the content, the reasons can be investigated and based on that information necessary adjustment can be made. Additionally, EEG can be utilised to create better social media marketing strategies. Companies can use this tool to interact with customers through media sites. By examining brain activity during the interaction to explore which part of the brain is activated, consumers' emotions can be measured. If particular types of interactions activate a specific brain area in a positive manner, future content can be modified based on that interaction.

2.1.2.2 Marketing strategy

A strategy is "a plan of action designed to achieve certain defined objectives" [Corey, (2003), p.1]. Sales volume, rate of growth, firm performance, market share, and return on investment are some firm objectives which can be improved with proper strategy (Corey, 2003). Marketing strategy includes the objectives related to the success of product, customer loyalty, increasing the customer base, and investing in the development of products. Marketing strategy scholars are on a quest to identify factors that can help improve these attributes. Most of this research depends heavily on secondary data. Unfortunately, this data is limited to public firms. It is also very difficult to understand how a TMT or CEO thinks when performing certain tasks or making certain decisions (Kashmiri et al., 2019). Neuroscience can make this task easier for researchers. For example, EEG can be used to measure the attention range (or emotions) of the CEO when making marketing decisions compared to operations or other decisions. This can help a researcher better understand the engagement level of the CEO in marketing versus others functions. Facial coding can also be used to track CEOs' reactions to various market activities. Thus, the authors encourage future researchers to use neuro marketing beneficially towards the strategy area of marketing.

2.1.2.3 Service marketing

The three unique features of services are heterogeneity, intangibility, and inseparability (Parasuraman et al., 1985). The inseparability of service indicates that production and consumption occur simultaneously, so it would be beneficial if service quality or service assessment were monitored when customers experience them. Traditionally, customers are asked to evaluate service at a later time, so they may not be able to convey all the emotions they experience during service interaction. Neuromarketing instruments can be used to better understand consumers' attitude towards service providers at the point of consumption.

Table 1 Published articles in various areas in neuromarketing

Areas	*Citations*
Advertising	Astolfi et al. (2009), Balconi et al. (2014), Cosic (2016), Custdio (2010), Dimpfel (2015), Vecchiato and Babiloni (2011), Klahr et al. (2006), Kumar and Singh (2015), Morin (2011), Murugappan et al. (2014), Nussbaum et al. (2012), Ohme et al. (2009), Orzan et al. (2012), Pileliene and Grigaliunaite (2017), Plassmann et al. (2007), Siefert et al. (2008), Vecchiato et al. (2012), Wei et al. (2018), Zhao et al. (2012)
Branding	Boldo et al. (2015), Brown et al. (2012), Cîrneci et al. (2014), Meyerding and Mehlhose (2018), Nakamura et al. (2016), Neto and Filipe (2016), Venkatraman et al. (2012), Walvis (2008), Yang et al. (2018)
Product design	Motte (2009), Wise and Preston (2010), Meyerding and Mehlhose (2018)
Marketing strategy	Burgos-Campero and Vargas-Hernández (2013)
Social media	None
Service marketing	Nasr et al. (2018)
Consumer behaviour	Berčík et al. (2015, 2016), Brown et al. (2012), Byun et al. (2005), Dapkevicius and Melnikas (2009), Golnar-Nik et al. (2019), Horska et al. (2016), Hubert and Kenning (2008), Kumar et al. (2016), Meyerding and Mehlhose (2018), Nasr et al. (2018), Neto and Filipe (2016), Osselaer (2004), Perrachione and Perrachione (2008), Pirouz (2004), Sebastian (2014)
Others	Agarwal and Xavier (2015), Avenanti et al. (2005), Barch (2006), Bercea (2012), Carr et al. (2003), Fortunato et al. (2014), Grosbras and Paus (2006), Harford (2003), Harris et al. (2018), Hsu (2016), Kulkarni et al. (2005), Kumar and Singh (2015), Lawrence et al. (2006), Lewis and Phil (2004), Madan (2010), Schaik (2014), Schleim and Roiser (2009), Sebastian (2014), Stanton et al. (2017), Vecchiato et al. (2012), Li et al. (2016), Wicker et al. (2003)

Vargo and Lushch (2004) expanded the service perspective with the service-dominant logic. The service dominant logic proposes that the customer is a co-creator of value. Companies can gain competitive advantages by the application of specialised skills and knowledge (operant resources) that results from effective collaboration with all entities. The authors propose that neuromarketing instruments can also be used to contribute to service provision. If value co-creation occurs by collaboration with customers, researchers can obtain more detailed information through neuroscientific tools. In the traditional manner, customers or employees may not express their thoughts clearly, or

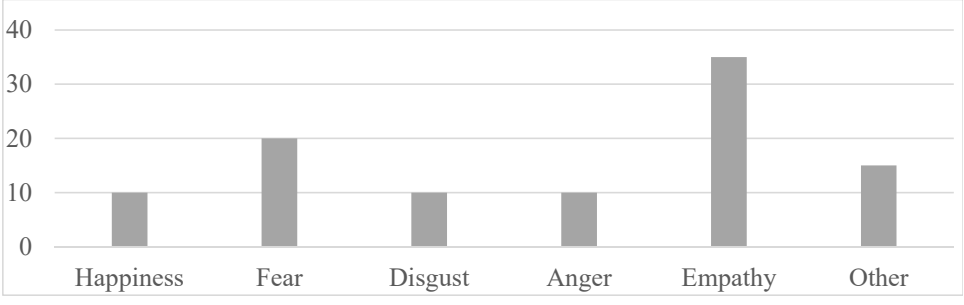
they may not want to share them. However, neuroscientific methods can help uncover more information. Summary of reviewed articles in each area are presented below (see Table 1).

2.2 Emotions studied in neuromarketing

Emotions play a significant role impacting our everyday life, from social communication to decision-making (Petrantonakis and Hadjileontiadis, 2010). Therefore, understanding individuals' underlying elements of the emotional pattern has generated considerable attention across different disciplines from medicine to marketing. To date, substantial research has been conducted to discover underlying causes of emotions by using neuroimaging tools such as fMRI and EEG, and biometric techniques such as eye-tracking (Adams et al., 2003; Batty and Taylor, 2003). Studies indicate that neural activities in human's brain vary across different basic emotions such as anger, disgust, sadness, happiness, and surprise. Therefore, it may not be possible to obtain this information through traditional methods such as surveys and interviews.

Neuroscientific tools and biometric instruments can help researchers observe individual' neural and eye-pattern activities that provide unconscious and conscious information. This section summarises various emotion types (happiness, disgust, anger, fear and empathy) that have been studied so far and gives suggestions on how they can be used in marketing. Percentage of published articles on emotions is shown below (see Figure 2).

Figure 2 Percentage of published articles on emotions (see online version for colours)



2.2.1 Past research

1 *Happiness*. Defined as the feeling of being pleased, happiness is associated likability, credibility, flexibility, energy, and self-efficacy (Lyubomirsky et al., 2005). Several studies have focused on the emotion of happiness in different disciplines like the happy facial expression versus other facial expressions (Calvo and Nummenmaa, 2009), frontal electrocortical and cardiovascular reactivity during happiness and anger (Waldstein et al., 2000), recognition of happiness and fear expressed by a whole body (De Gelder et al., 2004), and different amygdala responses to happy and fearful facial expression depending on selective attention (William et al., 2005).

   Schmid et al. (2011) explored whether happy and sad mood have an impact on emotion recognition task by using the eye-tracking method. According to the

findings, when volunteers are in a good mood, they process information more globally, not partially. Also, this study shows that men, as opposed to women, recognise emotions more accurately in a happy mood. Additionally, women tend to process information more globally than men. This study indicates that researchers can obtain invaluable information concerning participants emotional recognition process in terms of gender. Because women use more automatic and less analytic information processing (global information processing) during emotion recognition process (Hall et al., 2004; Schmid et al., 2011), one can develop advertising with more emotional elements if the target audience is women. If the target audience is men, they should put more analytical information since they are looking for more specific information before making a judgement.

2 *Fear*. Defined as an emotional response to threat, fear has an impact on some people's behaviours, causing them to look for ways to get rid of danger or threat (Tanner et al., 1991). Like other emotions, fear causes certain brain regions (e.g., Amygdala) to have higher activity (Adolphs, 2002; De Gelder et al., 2004). Amygdala brain regions region is not only capable of differentiating the presence of threat directed with facial expression, but also capable of processing vague threats (Adams et al., 2003). These results show that when participants feel fear, a particular region is strongly activated. In marketing, the fear appeal was used to promote various types of products such as mouthwash and deodorant, services like insurance and health issues such as cigarette cessations, smoking, and drug use (Morales et al., 2012). Even though most scholars have admitted that fear can persuade customers, there has been disagreement regarding the level of fear – strong, weak or moderate (Morales et al., 2012; Rotfeld, 1988; Tanner et al., 1991). Regardless of fear level, advertisers can gain insight into which types of fear generates more activity in the amygdala. On the basis of this information, they can adjust the fear theme in their ads.

3 *Disgust*: Defined as feeling of dislike, annoyance or disapproval, disgust is evoked by a different sort of stimuli with inhomogeneous content (Sarlo et al., 2005). Studies show that when subjects feel disgusted, certain behavioural reactions (e.g., staying away from disgusting events, situations or objects), physiological responses (e.g., decreased heart rate, increased galvanic skin rate, variation in finger temperature, brain activation in right hemisphere), and facial expressions (e.g., open mouth) can be observed (Rozin et al., 1993). Wicker et al. (2003) exposed his subjects to disgusting and pleasant smells, tracking their brain activity by fMRI. The finding indicates that the anterior insula was activated when subjects experienced disgusting odours and also while observing others' disgusting facial expressions. In marketing, Morales et al. (2012), studied the role of disgust in improving fear appeals, revealing that disgust enhances message persuasion if it is added to fear appeal. Thus, neuroscientific tools can help marketers in studying disgust related behaviours, helping them improve message persuasion.

4 *Anger*. Anger is defined as an intense feeling of desire for hurting or criticising someone. When people observe someone with an angry face, the orbital frontal region, the posterior part of the right gyrus cingula, the medial prefrontal cortex, the medial temporal gyrus of the left hemisphere are activated. Grosbras and Paus (2005) investigated brains' reaction to hand actions performed with emotion (neutral vs.

anger) and compared it with brain activity obtained by emotional face expressions (neutral and anger). The study shows that hand actions performed with emotions activate additional regions. In marketing, customers may display anger in response to delayed service, rude employees, and core customer service failure such as billing issues (Bougie et al., 2003). Extant marketing research reveals a correlation between dissatisfaction and anger (e.g., Folkes et al., 1987), leading to complaints (Roseman et al., 1994; Shaver et al., 1987) or taking actions like boycotting the brand, taking legal proceeding, complaining to third parties, expressing negative WOM, supporting competitors and so on (Stephens and Gwinner, 1998). The consequences of these actions could be detrimental to companies, thus needing them to take steps to recognise and prevent such anger. Using neuroscientific development, researchers can identify reasons leading to anger by employing neuroscientific tools to better identify how anger impacts consumers' behaviours.

5 *Empathy*. Empathy allows us to share the same emotion, pain, and feeling of others (Singer2006). Studies reveal that when observers see others receiving pain, the observers' neural responses were the same as those of participants experiencing pain. Fronto-insular lobe and the anterior cingulate lobe were activated in both observers and participants (Lloyd et al., 2004; Singer et al., 2004). Singer (2006) investigated whether empathic neural responses vary based on peoples' social behaviours such as fairness, using fMRI. Male and female participants were asked to observe how two confederates, playing an economic game fairly and unfairly. The results show that both men and women displayed the same empathy-pain activation in pain-related regions toward the fair player. However, men exhibited reduced empathy-pain activation in pain-related areas toward the unfair player, but an increased activation was observed in reward-related parts, which is associated with an expressed desire for revenge. This indicates that emphatic neural responses are impacted by social behaviours, particularly in men. In marketing, study on salesperson reveals that his/her empathic behaviour makes him/her more adaptive, further increasing sales performance (Spiro and Weitz, 1990) along with their behaviour when selling to friends (Beeler et al., 2019). Customers may develop conflicting emotions when they perceive unfairness (Singer, 2006). Marketers can use the tools described earlier to gain insight into what actions activate the empathy-related region of the brain and which actions activate the revenge-related region.

2.2.3 Future research

Neuromarketing researchers should explore more emotions like curiosity, amazement, interest, astonishment, uncertainty, annoyance, acceptance, delight, and tolerance which have not been given enough attention. Investigating these emotions can help expand the understanding of advertisers and practitioners regarding customers' preferences, reactions, and behaviours. Plutchik (2001) put the emotions of fury, rage, hostility, and annoyance under the emotion of anger, each of them having a different degree. Another study showed that content going more viral contains different levels of the same emotions (Libert and Tynski, 2013). They looked at 30 of the top 100 images of the year to explore which emotions each image activated per participant based on Plutchik's wheel of

emotions. The results suggested that positive emotions were more commonly revealed in the viral content than negative emotions. Marketing scholars can further explore the complexity of the dynamic interactions of these emotions using neuromarketing tools. Summary of the citations in various areas in shown below (see Table 2).

Table 2 Citations for analysis of emotions

Emotions	*Citations*
Happiness	Stein et al. (2002), Williams et al. (2005)
Fear	De Gelder et al. (2004), Stein et al. (2002), Sprengelmeyer et al. (1998), Williams et al. (2005)
Disgust	Smith et al. (2018), Sprengelmeyer et al. (1998), Wicker et al. (2003)
Anger	Angus and Harmon-Jones (2019), Grosbras and Paus (2005), Sprengelmeyer et al. (1998)
Empathy	Avenanti et al. (2005), Carr et al. (2003), Chierchia and Singer (2017), Decety and Lamm (2006), Lanzetta and Englis (1989), Lawrence et al. (2006), Singer (2006)
Other	Acuff (2005), Calvo and Nummenmaa (2009), Dimberg et al. (2000), Kalisch et al. (2005), Kringelbach and Berridge (2010), Kulkarni et al. (2005), Ochsner et al. (2002), Seifritz et al. (2003), Tarnowski et al. (2016), Zak (2017)

Figure 3 Percentage of tools used in research

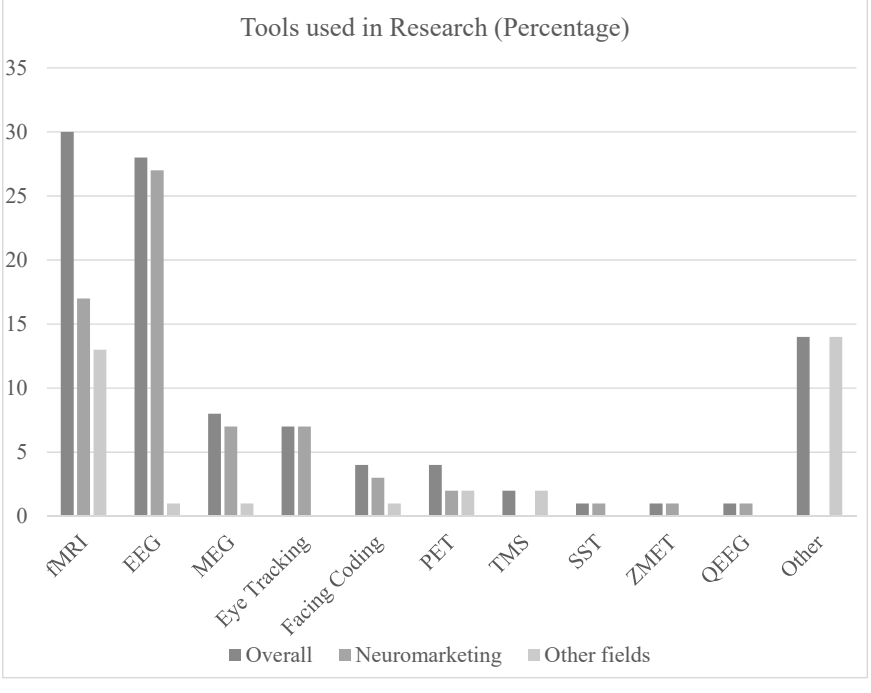


Table 3 Citations who used tools for research

Tool	*Neuromarketing*	*Other fields*
fMRI	Agarwal and Xavier (2015), Byun et al. (2005), Ciprian-Marcel et al. (2004), Cîrneci et al. (2014), Dapkevicius and Melnikas (2009), Klahr et al. (2006), Koller (2010), Kumar and Singh (2015), López (2016), Madan (2010), Meyerding and Mehlhose (2018), Motte (2009), Pirouz (2004), Schäfer (2005), Schleim and Roiser (2009), Smith et al. (2018), Stallen et al. (2010), Suomala et al. (2012), Venkatraman et al. (2012), Wise and Preston (2010)	Plassmann et al. (2007), Barch (2006), Lawrence et al. (2006), Singer (2006), Grosbras and Paus (2006), Kalisch et al. (2005), Lewis and Phil (2004), De Gelder et al. (2004), Wicker et al. (2003), Ochsner et al. (2002), Seifritz et al. (2003), Sprengelmeyer et al. (1998)
EEG	Agarwal and Xavier (2015), Astolfi et al. (2009), Balconi et al. (2014), Boldo et al. (2015), Berčík et al. (2015, 2016), Brown et al. (2012), Custdio (2010), Dapkevicius and Melnikas (2009), Dimpfel (2015), Golnar-Nik et al. (2019), Kumar and Singh (2015), Lewis and Phil (2004), Madan (2010), Mileti et al. (2016), Motte (2009), Murugappan et al. (2014), Nussbaum et al. (2012), Ohme et al. (2009), Pirouz (2004), Plassmann et al. (2007), Tarnowski et al. (2016), Vecchiato et al. (2011, 2012), Wei et al. (2018), Yang et al. (2018), Zhao et al. (2012)	Horska et al. (2016)
MEG	Dapkevicius and Melnikas (2009), Lewis and Phil (2004), Motte (2009), Pirouz (2004), Plassmann et al. (2007), Vecchiato et al. (2011)	Barch (2006)
Eye tracking	Cosic (2016), Dimpfel (2015), Berčík et al. (2016), Kumar and Singh (2015); Kumar et al. (2016), Li et al. (2016), Siefert et al. (2008)	None
PET	Pirouz (2004), Plassmann et al. (2007)	Barch (2006), Kulkarni et al. (2005)
TMS	None	Barch (2006), Avenanti et al. (2005)
Facial coding	Horska et al. (2016), Neto and Filipe (2016)	Williams et al. (2005)
SST	Agarwal and Xavier (2015)	None
ZMET	Byun et al. (2005), Nasr et al. (2018)	None
QEEG	Lewis and Phi (2004)	None
Other	Acuff (2005), Bercea (2012), Burgos-Campero and Vargas-Hernández (2013), Carr et al. (2003), Fortunato et al. (2014), Hsu (2016), Hubert and Kenning (2008), Meyerding and Mehlhose (2018), Morin (2011), Nakamura et al. (2016), Nasr (2014), De Oliveira et al. (2014), Orzan et al. (2012), Perrachione and Perrachione (2008), Renvoise and Morin (2005), Ruskin (2003), Schaik (2014), Sebastian (2014), Walvis (2008)	Decety and Lamm (2006), Dimberg et al. (2000), Harford (2003), Lanzetta and Englis (1989), Stein et al. (2002)

2.3 Tools used in neuromarketing

This section introduces different types of tools that have been used in the field of neuroscience and examines the advantages and disadvantages of each tool (fMRI, MEG, EEG, eye tracking, PET, SST, Facing Coding, ZMET, QEEG and TMS). These tools are divided into two sub sections: those which have been used in the neuromarketing research (past research) and those which have been rarely used (future research). Figure 3 depicts the percentage of each tool used in published research, whereas Table 3 lists the citations where the tool was used. Table 4, provides an overview of advantage and disadvantage of each tool.

Table 4 Advantages and disadvantages of tools used in neuromarketing

Tool: Brief	*Advantages*	*Disadvantages*
Past and current research		
Functional magnetic resonance imaging (fMRI): Used to examine brain function by incorporating magnetic and radio waves that generate a signal for viewing the brain structure in detail (Bercea, 2012).	Provides high spatial resolution (Plassmann et al., 2011; Zurawicki, 2010) and psychological processes interpretation of the brain (Reimann et al., 2011).	Very expensive (Ariely and Berns, 2010; Plassmann et al., 2011). Low temporal resolution, difficulty of application – subject cannot move during experiment (Plassmann et al., 2011; Zurawicki, 2010)
Magnetoencephalography (MEG): Records brain activity with good spatial resolution and a splendid temporal resolution by using magnetic potentials (Schwartz et al., 2010).	Creates a reliable measure for cognitive and affective responses (Wang and Minor, 2008). Measures perception, attention, and memory indirectly via cerebral. Addresses cerebral relationships.	Expensive (Ariely and Berns, 2010). Not well equipped at detecting the exact location of brain activity (Lee et al., 2009).
Electroencephalography (EEG) measures brain activity (Morin, 2011).	Measure the changes in the frequencies of electrical Braij activity (Wang and Minor, 2008). High temporal resolution (Ohme et al., 2011). Can compare left (negative emotional responses) with right (dominate positive emotional responses) hemispheres of the brain (Ohme et al., 2011; Plassmann et al., 2011). Cost is lower than MEG and fMRI (Ariely and Berns, 2010; Plassmann et al., 2011).	Does not have high spatial resolution, cannot pick up the exact location of neurons that are firing in the brains, in deeper structures (Morin, 2011). Can obtain activity data solely from superficial cortex surfaces (Zurawicki, 2010).
Eye Tracking: Contains either eyeglass (mobile) or a stationary eye tracker that picks up information where the subject is looking at (Cosic, 2016).	Easy to handle. Can be used for product design tests, web pages, email communication tests, marketing communication tests (Cosic, 2016).	Depends on the subject's eye condition (Wang and Minor, 2008). Not useful for all subjects.

Table 4 Advantages and disadvantages of tools used in neuromarketing (continued)

Tool: Brief	*Advantages*	*Disadvantages*
Past and current research		
Steady state topography: provides continuous recording of cognitive progress with high temporal resolution (Camfield et al., 2012).	Capable of picking up continuously rapid variations in brain activity (Camfield et al., 2012). Can measure consumer behaviour, video material effectiveness, engagement, emotional intensity, emotional valence and attention (Bercea, 2012).	Poor temporal resolution
Future research		
Positron emission tomography (PET): Measures the metabolic activity in the brain by injecting the subject with a radioactive substance.	Can measure sensory perception and valence of emotions (Bercea, 2012).	This method is invasive because of the application of a radioactive substance (Kenning and Plassman, 2005).
Facial Coding: Allows tracking facial reaction of the subject when he is exposed to stimuli (Schaik, 2014).	Allows the measurement of non-conscious responses, multiple muscle movements, action units as well as six core emotions such as anger, dislike, fear, sadness, surprise, envy, and smiles (Bercea, 2012).	The subject knows that he or she is being monitored to explore the facial expression to stimuli (Schaik, 2014), so emotions and reactions may be influenced by this awareness.
ZMET: extracts both conscious and unconscious thoughts by exploring peoples' non-literal or metaphoric expressions (Coulter and Zaltman, 1995)	Enlists multiple research techniques to tap consumers' minds (Christensen and Olson, 2002). Great reliability and validity (John et al., 2006; Zaltman, 1997).	Two significant drawbacks include its limited accessibility and difficulty to administer. ZMET can only be used by experts in the field since it involves their judgement as the procedure is not standardised. The process is labour intensive making it difficult to administer (Zaltman, 1997).
QEEG: involves "computer-assisted imaging and statistical analysis of the EEG for detecting abnormalities" (Coburn et al., 2006).	Widely been used in medical sciences to test and diagnose patients (Kaiser, 2006).	Duffy et al. (1994) listed a few issues with QEEG which include the colour maps used for QEEG being deceptive, their lack of required detail, and its sensitivity to artefacts. In spite of its drawbacks, these tools remain helpful not only to physicians but also to other practitioners who seek a better understanding of the human brain. Thus, this tool needs to be explored more in other areas, such as marketing.

Table 4 Advantages and disadvantages of tools used in neuromarketing (continued)

Tool: Brief	*Advantages*	*Disadvantages*
Future research		
Transcranial magnetic stimulation (TMS): A plastic case that has an electric coil placed near the head of the volunteer (Bercea, 2012).	Offers high temporal and spatial resolution (Schaik, 2014). Can detect causal inferences by examining the subject exposed to marketing stimuli (Bercea, 2012). Allows measuring attention, cognition, and changes in behaviour. Cost is lower than fMRI and PE (Bercea, 2012).	This tool does not allow pick up information about the cortical area activity close to neocortex (Kenning and Linzmajer, 2011).

Others: Along with the tools mentioned in Table 4, there are several other tools which have been used, although not as frequent as the ones mentioned above. These include CT/CAT (computerised tomography), MRI (nuclear magnetic resonance imaging), advertising self-assessment manikin (AdSAM), event-related potentials (ERP) and SC. The authors encourage marketing scholars to further explore these tools and utilise the advantages provided by these tools to evaluate the behaviour if individuals.

3 Implications and conclusions

Marketing researchers have recognised the benefits of neuroscience as evidenced by the growing literature in this area (Khushaba et al., 2013; Meckl-Sloan, 2015). However, little work has been done to bring these various studies together to offer a solid building block on which theory can be further developed in a rigorous manner. The authors conducted a multidisciplinary literature review to address this limitation.

The authors make several noteworthy contributions to the neuromarketing literature. First, they provide a unified perspective of the neuroscience research that's been conducted within the field of marketing. This facilitates the establishment of standardised research approaches within neuromarketing and responds to specific calls for such standards (Meckl-Sloan, 2015; Ulman et al., 2015). Second, they make a key contribution by identifying a number of future research opportunities within neuromarketing, such as the tools that can be employed, specific areas in marketing where the tools can be applied, and specific emotions that can be investigated to further improve marketing. Third, they provide additional guidance to neuromarketing scholars by discussing strengths and drawbacks associated with various tools, by introducing gaps in the areas of marketing where neuromarketing is yet to be improvised and emotions of consumers that are yet to be captured using neuromarketing. Finally, they make a unique contribution by also drawing articles from other disciplines where these tools are used that brings insights from other disciplines to marketing scholars.

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