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Tools in Marketing Research: Exploring Emotional Responses to Stimuli

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Abstract: Electromyography (EMG), galvanic skin responses (GSR), and electrocardiogram (ECG) tools have been used to investigate emotional responses to marketing stimuli, encompassing advertisements, product packaging, and brand logos. However, despite the widespread application of EMG, GSR, and ECG tools in neuromarketing research, a comprehensive synthesis of their collective impact remains conspicuously absent. Addressing this gap is the primary goal of the present review paper, which systematically scrutinizes recent studies employing EMG, GSR, and ECG to assess emotional responses to marketing stimuli. Employing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, relevant articles were meticulously extracted from the Scopus database, spanning the years 2009 to 2022, including twenty articles for detailed analysis. The outcomes of this review underscore the unique insights offered by these tools into emotional reactions, emphasizing that their collective utilization can afford a more comprehensive understanding of these intricate processes. This propels advancements in comprehending the pivotal role of emotions in consumer behavior and serves as a guidepost for future research directions in this burgeoning field. Ultimately, this paper aims to furnish a broad understanding and detailed insights into the current trends within neuromarketing research, specifically employing EMG, GSR, and ECG tools.

Keywords: emotional responses; neuromarketing; consumer behavior; EMG; GSR; ECG.

JEL classification: M30; M31; M39; O3.

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1. INTRODUCTION

While self-report methods have traditionally been used to understand consumer decision-making (Alvino *et al.*, 2020; Alsharif *et al.*, 2021c), recent neuroscience studies have revealed that decision-making primarily occurs in the brain's deep structures, such as the limbic and reptilian layers (Zaltman, 2000). This may explain why consumers often fail to predict their future choices and why their behavior may not align with their reported preferences (Alsharif *et al.*, 2021c). As a result, understanding the mechanisms of decision-making has become a crucial area of interest for researchers and marketers (Vecchiato *et al.*, 2013; Boksem and Smidts, 2015; Alsharif *et al.*, 2020a). To better understand consumer decision-making, marketers have turned to neurophysiological and physiological tools such as GSR, ECG, and EMG (Stanton *et al.*, 2017). This approach, known as "consumer neuroscience" or "neuromarketing," allows marketers to gain insights into consumers' emotional and cognitive responses to marketing stimuli (Pilelienė *et al.*, 2022; Alsharif and Pilelienė, 2023; Alsharif *et al.*, 2023f). While the usage of physiological tools has increased in recent years, there is still much to learn about how they can be applied to improve marketing strategies (Alsharif *et al.*, 2022e). For example, more research is needed to understand how these tools can accurately predict consumer behavior and preferences. Additionally, ethical considerations must be considered when using these tools, as they may involve collecting sensitive data about consumers (Stanton *et al.*, 2017; Alsharif *et al.*, 2022c; Alsharif *et al.*, 2023c).

The neuromarketing concept is connected to brain activities to understand consumers' subconscious and unconscious responses (Alsharif *et al.*, 2023a). Although "neuromarketing" emerged in 2002, some companies, such as Pepsi Co., used neurophysiological and physiological technology before 2002 to solve marketing issues (Cherubino *et al.*, 2019; Alsharif *et al.*, 2021b). Therefore, neuromarketing is defined as applying neurophysiological and physiological technology to better understand customers' behavior toward stimuli of the marketing environments (Plassmann *et al.*, 2015; Alsharif *et al.*, 2022d). For example, neurophysiological tools such as fMRI and EEG can measure the neural correlates of customers' behaviors, such as decision-making, emotions, attention, and memory, to the marketing environment (Alsharif *et al.*, 2022e). On the other side, physiological tools such as EMG, GSR, and ECG enable the measurement of customers' emotional responses toward brands, ads, or even packaging features of a brand (Cherubino *et al.*, 2019; Alsharif *et al.*, 2021d).

This scholarly paper aims to shed light on the pivotal role of EMG, GSR, and ECG tools in unraveling customers' emotional responses towards marketing stimuli. By leveraging the capabilities of EMG, researchers can capture both visible and invisible facial muscle movements, providing valuable insights into emotional expressions (Lang *et al.*, 1995; Bolls *et al.*, 2001; Larsen *et al.*, 2003). Similarly, GSR allows for measuring autonomic nervous system excitement in response to marketing stimuli, while ECG records heartbeat activations during exposure to such stimuli. Together, these tools enable the measurement of emotional responses, encompassing dimensions like pleasure/displeasure, excitement, and arousal, towards various marketing stimuli, including brands and advertisements (Missaglia *et al.*, 2017; Alsharif *et al.*, 2023b). Given the significance of measuring emotions and feelings in the marketing environment, this paper addresses the existing gap in the literature by focusing on GSR, EMG, and ECG and providing an up-to-date overview of these tools. It further delves into an extensive discussion of relevant articles that have employed these tools in

neuromarketing studies. Therefore, the primary contributions of this review paper can be summarized as follows:

(1) Investigating how the theoretical foundations of EMG, GSR, and ECG contribute to a more profound understanding of customer emotions in marketing research.

(2) Exploring the insights and findings derived from studies employing EMG, GSR, and ECG to measure emotional responses to various marketing stimuli, including brands, advertisements, and products.

(3) Gaining insights into effectively using EMG, GSR, and ECG through new references, assisting scholars in expanding knowledge and expertise in this domain.

Accordingly, three research questions were established to justify the structure and to gain the full view of the existing scientific research in the analyzed domain:

(1) How do EMG, GSR, and ECG theoretical foundations deepen the understanding of customer emotions in marketing research?

(2) What insights arise from studies using EMG, GSR, and ECG to measure emotional responses to marketing stimuli?

(3) How can scholars effectively use EMG, GSR, and ECG to expand expertise in investigating customer emotions in marketing?

The structure of this review paper is thoughtfully organized. Section 2 presents the literature reviews of the physiological tools: EMG, GSR, and ECG. Section 3 presents the methodology used to select and extract relevant articles. Section 4 discusses the contributions and findings of studies that have employed physiological tools in neuromarketing research. Finally, Section 5 presents the concluding remarks, summarizing the key insights gained from this review paper. Section 6 presents limitations and future agendas.

2. LITERATURE REVIEW

2.1 Electromyography

According to Ekman (2004), facial expressions are a powerful communication medium, enabling individuals to convey a wide range of emotional states, such as happiness, sadness, and more (Alsharif *et al.*, 2022a). Consequently, faces play a crucial role in deciphering unspoken emotions and serve as the primary indicator of one's emotional state (Salichs *et al.*, 2006). Facial expressions are significant in interpersonal communication and everyday interactions with the marketing environment (Missaglia *et al.*, 2017). Simply put, a smile generally signifies happiness, while a frown indicates sadness or anger (Missaglia *et al.*, 2017). Therefore, facial expressions serve as a reflection of consumers' emotional states.

In marketing contexts, analyzing facial expressions is of great importance for marketers and researchers seeking to understand customers' emotional responses to marketing stimuli. This analysis provides valuable insights into customers' emotional states (Cherubino *et al.*, 2019). Customers' facial expressions convey both the emotional tone and the level of arousal experienced (Ekman, 2004). For instance, movements of the mouth and eyebrows can indicate pleasure or displeasure, as well as ongoing communication (Mutlu *et al.*, 2009). Thus, facial expressions offer feedback regarding others' opinions and discussions (Cherubino *et al.*, 2019). EMG is a convenient tool for capturing emotional valence and arousal (Hadinejad *et al.*, 2019), focusing on both visible and hidden facial muscles, including the zygomatic and corrugator muscles (Lang *et al.*, 1995; Bolls *et al.*, 2001; Larsen *et al.*, 2003). Moreover, it

enables the measurement and identification of physiological properties of facial muscles, encompassing voluntary and involuntary responses (Ohme *et al.*, 2011). Activation of the zygomatic muscles is associated with positive stimuli and can influence purchasing decisions (Somervuori and Ravaja, 2013; Alsharif *et al.*, 2020b). Conversely, the corrugator muscles are linked to negative stimuli (Larsen *et al.*, 2003; Missaglia *et al.*, 2017). By employing EMG, researchers can gain deeper insights into consumers' emotional valence and arousal, enabling a better understanding of their responses to marketing stimuli. Therefore, this tool provides a nuanced understanding of the emotional aspects of consumer behavior, allowing marketers to tailor their strategies accordingly.

2.2 Galvanic skin response

GSR tool, also known as electrodermal activity (EDA), measures the autonomic nervous system (ANS), providing insights into consumers' internal emotional states (Cherubino *et al.*, 2019; Barquero-Pérez *et al.*, 2020; Lajante *et al.*, 2020; Alsharif *et al.*, 2021a). Furthermore, it is non-invasive and has become an essential component in the field of neuromarketing, offering a reliable method for measuring emotional arousal and cognitive engagement in response to marketing stimuli (Fortunato *et al.*, 2014; Barquero-Pérez *et al.*, 2020). (Dawson *et al.*, 2017) defined GSR as a temporary increase in the skin's electrical conductivity, indicating heightened activity of the sweat glands. Notably, the high concentration of sweat glands on the palms and soles of the feet makes GSR particularly suitable for studying consumer decision-making (Nourbakhsh *et al.*, 2017). These glands are mainly stimulated in response to emotional events such as stress, with a larger concentration in the face, palms of hands, soles of feet, and armpits, with the palms of hands being the preferred location for the GSR measurement (Durán-Acevedo *et al.*, 2021).GSR, along with other neuromarketing techniques such as eye tracking and EEG, has been employed to understand consumer behavior, emotional responses, and decision-making processes (Mañas-Viniegra *et al.*, 2020; Mengual-Recuerda *et al.*, 2020).

The use of GSR has been observed in various marketing contexts, including the evaluation of the effect of emotional fatigue on the purchase process (Andrii *et al.*, 2019), co-creation with consumers for packaging design validation (López-Mas *et al.*, 2022), and the influence of music on advertising effectiveness (Cuesta *et al.*, 2018). Additionally, GSR has been recognized as a valid tool for measuring consumer decision-making and emotional arousal (Alvino *et al.*, 2020; Alsharif *et al.*, 2023d). The integration of GSR with other physiological and neuroimaging tools has provided valuable insights into consumer behavior, emotional responses, and the effectiveness of marketing stimuli (Cuesta *et al.*, 2018; Giakoni *et al.*, 2022; Martinez-Levy *et al.*, 2022; Lei *et al.*, 2024). Therefore, GSR plays a crucial role in providing objective and real-time data to understand consumer responses, which is essential for guiding marketing strategies and improving consumer satisfaction in various industries, including tourism, hospitality, and product packaging (Vergura and Luceri, 2018; De-Frutos-Arranz and López, 2022). The widespread use of GSR in neuromarketing research underscores its significance as a tool for understanding consumer behavior and emotional responses, thereby contributing to the development of more efficient marketing campaigns and strategies.

2.3 Electrocardiogram

The electrocardiogram (ECG) is a valuable tool in neuromarketing research, often used in conjunction with other biometric tools to measure the heart's electrical activity (Sung *et al.*, 2020). Furthermore, the ECG is categorized as a physiological tool used in neuromarketing research, which is used to gauge the consumer's emotional responses and experiences toward marketing stimuli (Alvino *et al.*, 2020; Alsharif *et al.*, 2022b; Alsharif *et al.*, 2023a). For example, during exposure to marketing stimuli, ECG can record the activations of the heart rate (Baraybar-Fernández *et al.*, 2017; Barquero-Pérez *et al.*, 2020). Heart rate is commonly regarded as a reliable indicator of emotional valence. For example, the study by Baldo *et al.* (2022)demonstrated that heart rate and self-reported arousal are associated with ad recognition, supporting the relationship between heart rate and emotional valence. Additionally, Yarosh *et al.* (2021)revealed that customer choice is accompanied by a change in emotional valence, from negative emotions to positive ones, suggesting a correlation between emotional valence and heart rate in consumer decision-making.

Moreover, advancements in wearable ECG devices have expanded the opportunities for marketing researchers to gather real-time and ecologically valid data on consumer experiences, thereby enhancing the understanding of consumer behavior (Casado-Aranda and Sanchez-Fernandez, 2022). In addition, integrating ECG with other neuroscientific tools, such as EEG, has provided specific insights into consumer behavior, emotions, and decision-making processes (Harris *et al.*, 2018; Dursun and Goker, 2019). The application of ECG in neuromarketing has also been acknowledged in various industries, with a growing number of specialized neuromarketing research companies catering to an impressive list of brands across different product categories (Plassmann *et al.*, 2007). The ECG tool plays a crucial role in neuromarketing by providing valuable insights into consumer emotions, attention, and experiences, thereby contributing to a deeper understanding of consumer behavior and decision-making processes.

EMG, GSR, and ECG tools are convenient for measuring the customers' behaviors, such as emotional reactions toward marketing stimuli such as brands, logos, ads, packaging features, and color. Undoubtedly, EMG, GSR, and ECG tools have advantages (e.g., providing more valuable data) and disadvantages (e.g., subjectivity). Table no. 1 shows the summary of physiological tools, for example, what they measure, when they are used, advantages/disadvantages, and the cost of each tool.

Table no. 1 – A summary of EMG, GSR, and ECG tools.

Tool	*Description*
EMG	***What is it measured?*** To measure the facial expressions of customers toward marketing stimuli such as ads or brands. ***When is it used?*** This technique assesses brand recall, analyzes video materials, and examines consumers' reactions towards various marketing stimuli, including advertisements. ***Pros:*** This method demonstrates the capability to capture and analyze both visible and invisible movements of facial muscles, providing insights into emotional valence and arousal. Moreover, it exhibits high sensitivity and accuracy in detecting and interpreting various facial muscle movements. ***Cons:*** Subjectivity. ***Cost:*** Low-Moderate.
GSR	***What is it measured?*** Emotional arousal, sweat glands. ***When is it used?*** This technique is used to predict market performance.

Tool	*Description*
	Pros: The capacity to quantify the level of emotional arousal and make more accurate predictions regarding market performance surpasses the reliability of self-reported measures and offers a cost-effective solution. ***Cons:*** There are limitations in using this approach to determine emotional valence, as it struggles to differentiate between emotions such as excitement and stress, which can appear similar. Furthermore, external environmental factors, such as temperature and humidity, can exert an influence on the obtained results. Additionally, the time required for obtaining results, typically ranging from 2 to 3 seconds, can introduce inconsistencies in the outcomes. ***Cost:*** Low-Moderate.
ECG	***What is it measured?*** Emotions and emotional engagement during choice processes. ***When is it used?*** It is used to test movie trailers, website design, and ads. ***Pros:*** This non-invasive and portable tool offers a cost-effective means of acquiring valuable information about individuals' emotional responses to marketing stimuli. ***Cons:*** It presents a challenge to accurately ascertain real-time emotional states due to the inherent delay between physiological responses and brain activity, resulting in a lag of several seconds. ***Cost:*** Moderate.

Sources: conducted by authors

3. METHODS

The research followed the PRISMA protocol to find relevant papers (Page *et al.*, 2021). This study aims to comprehensively identify relevant articles that delve into the utilization of GSR, ECG, and EMG in neuromarketing activities to fill the existing gap. Endeavoring to answer the research questions, the current study starts by extracting articles from the Scopus database on April 20, 2023. The procedure used in the study enabled the identification of 20 open-access articles that were published between 2009 and December 2022. The reason for selecting the open-access articles is that this paper is conducting a content analysis of the selected articles.

The authors directed their attention exclusively towards articles employing GSR, ECG, and EMG tools, a period chosen due to a notable surge in publications during this span. Furthermore, the inclusion criteria were limited to articles written in English, given its predominant usage in the field. The article selection process, delineated in Figure no. 1, outlines the meticulous steps taken in the curation of papers ultimately included in the study.

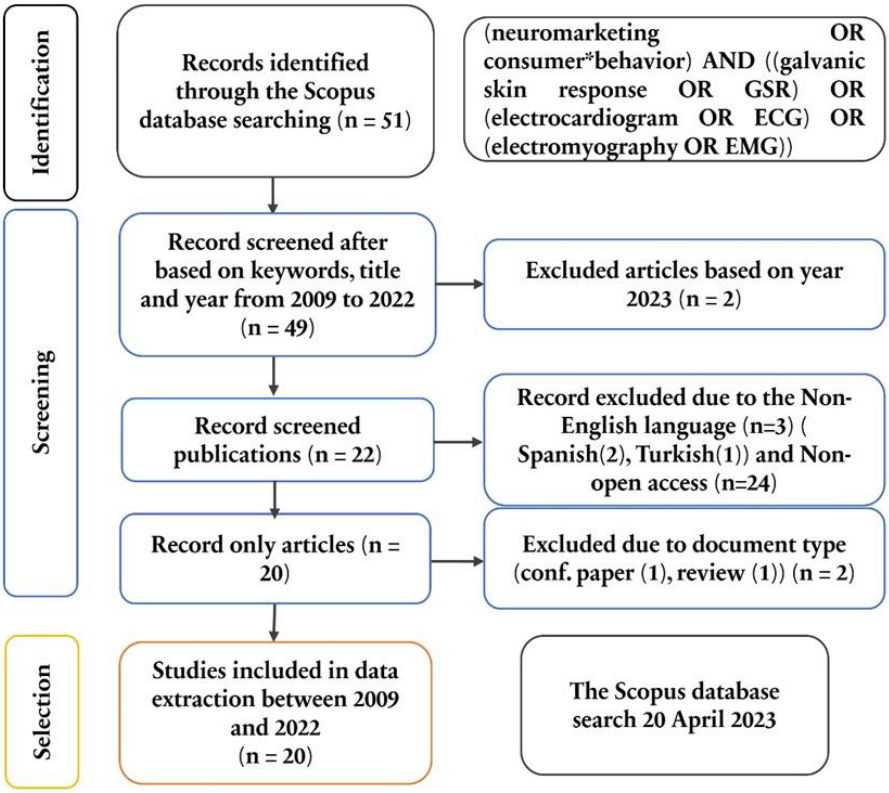

Figure no. 1 – Extraction articles process from Scopus database
Sources: conducted by authors

4. RESULTS AND DISCUSSION

4.1 The current trend in physiological monitoring technology (GSR, EMG, and ECG)

GSR is notably employed for assessing emotional reactions to advertisements, offering marketers insights into the emotional impact of their content (Vences *et al.*, 2020). Emotional information aids in crafting more emotionally resonant and effective advertising strategies. For example, Poels and Dewitte (2019); Alsharif (2023) emphasize the importance of emotions in advertising, highlighting that effective advertising messages touch the consumer's heart. Cui (2019) supported this by stating that emotional advertising that resonates with consumers influences their beliefs and desires better than logic-based advertising. Furthermore, Kemp *et al.* (2020) suggested that advertising is most effective when it stimulates logic by providing information and invokes emotions by connecting with the buyer. Additionally, Sanchez-Comas *et al.* (2021) found that advertisements with emotional content are more likely to be remembered than purely informative ones, as they actively engage viewers' emotions, contributing to better message assimilation. Additionally, GSR is utilized

to gauge consumer engagement during marketing interactions, providing real-time data on how individuals respond emotionally to products, services, or campaigns (Wei *et al.*, 2018; Cimtay *et al.*, 2020; Raheel *et al.*, 2020). This facilitates the creation of content that maximizes consumer engagement.

EMG plays a crucial role in evaluating the physical and emotional responses to product design and packaging. For example, EMG has been used in marketing studies to evaluate customer reactions to various stimuli, including different packaging designs, spatial orientation of attention, and emotional and cognitive impacts on the brain (Cherubino *et al.*, 2019; Alsharif *et al.*, 2022e; Alsharif *et al.*, 2023d). Furthermore, emotional responses to packaging information have been studied less frequently than intrinsic product properties (Gutjar *et al.*, 2015). In a study on emotional responses towards food packaging, self-report, and physiological measures were used to assess emotional responses to different food packaging elements, such as colors, images, and typefaces (Liao *et al.*, 2015). Additionally, research has shown that anxiety-inducing product packaging design influences food product interaction and eating behavior, with evidence suggesting that suppressing emotional regulation when exposed to such designs results in increased eating (Ilicic and Brennan, 2022). Understanding the impact of packaging design on consumer perceptions and purchase behavior is crucial for designers and marketers to satisfy consumer needs and potentially increase sales volume (Simmonds and Spence, 2017). Moreover, packaging design plays a significant role in consumer recycling behavior and can influence consumers' willingness to purchase products (Nemat *et al.*, 2019). Information provided on or in the food packaging can influence consumers' expectations and emotional responses (Gunaratne *et al.*, 2019). Furthermore, packaging design has been found to affect customer perception of a product, emphasizing the importance of effective packaging design in shaping consumer perceptions (Fatchurrohman *et al.*, 2022). Additionally, good packaging design for food products can attract consumers to buy the product, indicating the crucial role of packaging in consumer decision-making (Ahmad *et al.*, 2022). By analyzing facial muscle activity, marketers gain insights into the strength of positive or negative emotional associations with a particular brand or logo (Alsharif *et al.*, 2020b). EMG plays a crucial role in evaluating both the physical and emotional responses to product design and packaging. It provides valuable insights into consumer reactions to packaging stimuli, including emotional and cognitive impacts, and influences consumer perceptions and behaviors.

Electrocardiogram (ECG) monitoring in marketing is particularly focused on measuring stress levels during consumer decision-making processes. Understanding how stress influences purchasing behaviors allows marketers to design strategies that alleviate stress and enhance overall customer experiences. For instance, research has shown that shopping stress negatively affects consumers' purchase likelihood, making it essential for marketers to address stress factors in the shopping environment (Albrecht *et al.*, 2017). Additionally, the dark side of new-age technologies can contribute to customer technostress, which in turn influences purchasing behaviors, highlighting the need for marketers to consider the impact of technology on customer stress (Kumar *et al.*, 2022). Moreover, stress has been found to significantly impact customer satisfaction, particularly in the mall experience, emphasizing the importance of addressing stress to enhance overall customer satisfaction (Lucia-Palacios *et al.*, 2020). Furthermore, providing products and services that reduce customers' negative emotional attachments to work can contribute to promoting public health and well-being, indicating the potential for marketers to design strategies that alleviate work-related stress for

customers (Chen *et al.*, 2022). ECG is also applied to evaluate the physiological responses to various aspects of the customer journey, providing valuable data on the impact of interactions with a brand or product on consumer well-being. For instance, the capability of devices such as the Apple Watch to capture single-lead ECGs demonstrates the increasing integration of ECG technology in consumer-oriented products, further emphasizing its relevance in understanding consumer health and behavior (Wyatt *et al.*, 2020). Furthermore, consumers' decision-making process is influenced by various factors, including social media interactions, marketing strategies, and individual characteristics (Gupta, 2019; Zhang *et al.*, 2021), all of which can be measured and analyzed through neuroscientific and physiological techniques. This highlights the potential for ECG to provide valuable insights into the complex interplay of psychological, social, and individual factors that shape consumer decision-making processes (Kim *et al.*, 2016; Jamil *et al.*, 2022).

Across GSR, EMG, and ECG, the overarching trends include a move towards personalized marketing strategies, the integration of data analytics for insightful interpretation, and a heightened awareness of ethical considerations in the collection of physiological data for neuromarketing purposes.

4.2 Overview of selected articles

Neurophysiological and physiological methods have become essential tools for both researchers and practitioners, offering an in-depth exploration of consumer loyalty, perception, and brand preferences in comparison to their counterparts (McClure *et al.*, 2004; Plassmann *et al.*, 2007; Reimann *et al.*, 2012; Venkatraman *et al.*, 2015; Guo *et al.*, 2018; Alsharif *et al.*, 2021d; Alsharif *et al.*, 2023e). These approaches are extensively applied in marketing research to identify effective communication channels, including television, radio, Facebook, Twitter, and others, for successful advertising campaigns and to unveil implicit gestures (Fugate, 2007; Alsharif *et al.*, 2023a). For instance, GSR gauges autonomic nervous system (ANS) excitement in response to emotional stimuli such as advertisements (Alsharif *et al.*, 2023d). Another technique, EMG, assesses emotional valence and arousal evoked by advertising, products, and brands (Liaudanskaitė *et al.*, 2018; Lajante *et al.*, 2020; Ahmad *et al.*, 2022). EMG has been employed to evaluate the effectiveness of mass media platforms (e.g., TV, radio) or social media platforms (e.g., Facebook, Twitter, YouTube) in advertising campaigns, capturing subtle expressions (Fugate, 2007). Numerous studies e.g., Lewinski (2015); McDuff *et al.* (2015); Venkatraman *et al.* (2015); Missaglia *et al.* (2017); Liaudanskaitė *et al.* (2018); Lajante *et al.* (2020) have utilized physiological tools like EMG to measure consumers' emotional states (e.g., pleasure/displeasure, arousal) concerning ad effectiveness, comparing factors such as celebrity spokespersons versus regular individuals.

Furthermore, other studies e.g., Vecchiato *et al.* (2010); Reimann *et al.* (2012); Baraybar-Fernández *et al.* (2017); Cartocci *et al.* (2017); Guixeres *et al.* (2017); Leanza (2017); Halkin (2018); Andrii *et al.* (2019); Barquero-Pérez *et al.* (2020); Calvert *et al.* (2020); Herrador *et al.* (2020) have employed GSR and ECG to measure consumers' responses to marketing stimuli like advertisements and brands. These techniques offer valuable insights into the emotional aspects of consumer behavior and can potentially improve marketing strategies and campaign effectiveness. Table no. 2 shows the content analysis of the selected articles.

Table no. 2 - Summary of the EMG, GSR, and ECG studies in marketing

References	Tools	Contributions	Findings
Martinez-Levy *et al.* (2022)	EEG, HR, GSR, ET	To improve nonprofit ad effectiveness by assessing cognitive and emotional responses to TV ad stimuli	Adjusting message framing in nonprofit ads boosts effectiveness by triggering stronger emotional and cognitive responses.
Awan *et al.* (2022)	EEG, ECG, GSR	To develop an ensemble learning method using physiological signals for emotion mapping.	The deep learning ensemble achieved a record 94.5% accuracy in emotion mapping, surpassing other state-of-the-art techniques in emotion detection.
Giakoni *et al.* (2022)	ECG, GSR, ET	To propose a new research methodology to assess the effectiveness of ads in esports.	The new metrics highlighted their usefulness in optimizing ad/brand placement during esports broadcasts.
Levrini and Jeffman dos Santos (2021)	EMG, ET	To offer fresh perspectives on the evaluation of consumers' perception regarding the brand of retail stores.	The significant impact of the conscious pricing factor on their inclination to make a purchase.
Lajante *et al.* (2020)	GSR, EMG	To examine pleasure or displeasure of the customers' behaviors towards ads.	Pleasure and displeasure positively impact customers' behaviors and attitudes towards commercial ads.
Barquero-Pérez *et al.* (2020)	ECG, GSR	To analyze six distinct ads and get indices that assess the functioning of the ANS.	Each ad produced different emotions, such as disgust, anger, surprise, rationality, and sadness.
Calvert *et al.* (2020)	Impulse Test	To examine emotional responses towards dynamic visual stimuli, such as movie clips or TV ads.	The Impulse Tests technique has ability to record a set of general emotions and specific feelings while watching visual stimuli.
Herrador *et al.* (2020)	EDA/ GSR	To evaluate attentional and emotional reactions for differential applications in marketing strategies.	Both male and female participants initially showed strong activation to stimuli, yet the male group exhibited decreased activation during the critical section of the video.
Andrii *et al.* (2019)	GSR	To investigate the emotional fatigue in the store and its impact on purchase decision-making.	The emotional fatigue is influenced by the store's atmosphere and consumers' emotional state.
Halkin (2018)	GSR, ECG	To estimate the consumers' emotional fatigue during the visit to the shop.	The act of waiting in the cashier queue led to an increase in the fatigue index in shops, while it led to a decrease in fatigue levels during the journey back home.
Liaudanskaitė *et al.* (2018)	EMG	To measure the intensity of the customer's emotions toward static advertising.	The valence and arousal significantly influence the effectiveness of advertisements.

References	Tools	Contributions	Findings
Baraybar-Fernández *et al.* (2017)	ECG, GSR	To explore the emotional messages on commercial attractiveness.	The ad containing sad messages among the participants emerged as the most captivating commercial.
Leanza (2017)	GSR	To compare the consumers' cognitive, emotive, and preference toward traditional and Virtual Reality (VR) TV commercials.	VR experiences significantly affect skin conductance signals, with a strong correlation to explicit consumer preference evaluations.
Cartocci *et al.* (2017)	GSR, ECG, EEG	To investigate the antismoking advertising campaigns and emotional perception.	Symbolic style strongly influences the approach-withdrawal index, while "fear-arousing appeal" images rank highest and narrative style scores lowest on the effort index.
Missaglia *et al.* (2017)	EMG	To identify the predictive percentage of participants toward violent and non-violent video social ads.	Around 30% favored non-violent social ads, with a tenfold higher likelihood of selecting them compared to those experiencing anger, reported by 64.3%.
Guixeres *et al.* (2017)	ECG, ET, EEG, Survey	To investigate the effectiveness of ads (e.g., liking ads) and the number of views on YouTube channels.	There is a strong relationship between neuroscience metrics, self-reported ad effectiveness (e.g., liking ads), and the number of views on YouTube.
Lewinski (2015)	EMG	To examine if the facial expressions toward YouTube videos can predict their popularity among users of social media.	The percentage of happiness or sadness and surprise expressions was 61%-86%, respectively.
McDuff *et al.* (2015)	EMG	To predict facial responses to evaluate ad effectiveness, including metrics such as ad liking and purchase intention.	The predictive percentage of ad liking accuracy was 85%, while purchase intention was 78%.
Reimann *et al.* (2012)	GSR	To measure the emotional arousal toward their beloved brands.	Increasing emotional arousal and increasing inclusions of close brans over time.
Vecchiato *et al.* (2010)	GSR, ECG, EEG	To investigate brain activity and emotional engagement toward TV ads.	TV ads elevated heart rate and theta band cerebral activity (left hemisphere), with no observable change in GSR values.

Note: EDA; Electrodermal Activity, EEG; Electroencephalography, ET; Eye-tracking, HR; Heart rate

5. CONCLUSIONS

In recent years, there has been a significant upsurge in the interest among marketers and advertisers in better understanding customers' emotions. Utilizing EMG, GSR, and ECG in neuromarketing yields profound insights into customers' emotional responses towards various

marketing stimuli, including logos, brands, advertisements, and packaging features. EMG, measuring muscle activity, plays a pivotal role in assessing emotional responses through facial expressions, offering marketers a nuanced understanding of consumer engagement with advertisements, brands, and products. GSR, detecting changes in skin conductance, proves effective in pinpointing emotional arousal and evaluating the intensity of reactions, aiding marketers in identifying impactful campaign elements. ECG, measuring heart activity, contributes to comprehending consumer reactions' emotional and cognitive dimensions. Changes in heart rate serve as indicators of emotional engagement, allowing marketers to gauge stimuli impact on consumer perception. Collectively, these tools provide a comprehensive approach to neuromarketing, unveiling intricate connections between physiological responses and consumer preferences. By deciphering these connections, neuromarketers can tailor strategies for more impactful and resonant marketing campaigns. These tools' ongoing refinement and integration with neurophysiological methodologies (e.g., EEG, fNIRS, etc.) highlight their potential to significantly influence the future landscape of consumer research and marketing strategies.

Furthermore, ensuring the accurate application of electromyography (EMG), galvanic skin response (GSR), and electrocardiogram (ECG) in neuromarketing is crucial for obtaining reliable insights. Attention to detail, such as electrode placement, signal interpretation, and methodological consistency, is essential. Standardized procedures, clear guidelines, and addressing potential sources of variability contribute to the credibility of these physiological measures in providing meaningful and accurate insights into consumer behavior and emotional responses. In addition, these tools have proven reliable in capturing and analyzing customer emotions within the marketing environment, illuminating connections between customers and their surroundings and revealing underlying emotional states, whether positive or negative.

The theoretical foundations of EMG, GSR, and ECG significantly contribute to deepening the understanding of customer emotions in marketing research. By measuring muscle activity, EMG provides insights into the facial expressions associated with emotions, offering a non-intrusive window into consumers' emotional responses. GSR measures skin conductance, reflecting changes in arousal levels and providing valuable data on emotional intensity. ECG offers insights into physiological arousal and emotional valence. Together, these tools create a multidimensional understanding of customer emotions, allowing researchers to decipher both the cognitive and affective components of consumer responses to marketing stimuli.

Studies utilizing EMG, GSR, and ECG to measure emotional responses to marketing stimuli have yielded insightful findings. EMG studies reveal nuanced facial expressions associated with positive or negative emotions, aiding in understanding consumer preferences and engagement. GSR studies provide insights into emotional arousal levels, helping identify the intensity of emotional responses triggered by marketing content. ECG studies contribute to understanding the physiological aspects of emotional responses, offering valuable information on consumers' emotional valence and arousal. The integration of these physiological measures allows for a holistic interpretation of emotional experiences, providing marketers with a comprehensive understanding of how various stimuli impact consumers emotionally.

Scholars can effectively use EMG, GSR, and ECG to expand their expertise in investigating customer emotions in marketing through several strategies. First, by staying abreast of technological advancements in these tools, scholars can leverage the latest

developments for more precise and detailed measurements. Second, interdisciplinary collaborations with experts in psychology, neuroscience, and data analytics can enrich the interpretation of physiological data, enhancing the depth of emotional insights. Additionally, scholars can engage in empirical research projects that apply these tools in diverse marketing contexts, building a robust knowledge base and refining methodologies for future studies. Lastly, the integration of traditional survey-based methods with physiological measures allows for a comprehensive understanding of the interplay between conscious and subconscious emotional responses, offering a more holistic approach to investigating customer emotions in marketing research.

6. LIMITATIONS AND FUTURE AGENDAS

6.1 Limitations

The objective of the paper was to alleviate methodological constraints within the study; however, despite concerted efforts, some limitations persisted, prompting recommendations for future research endeavors. The study was exclusively centered on the neuromarketing field, deliberately excluding consumer neuroscience and English articles published in journals within the timeframe of 2009 to 2022, as indexed in the Scopus database. While designed to ensure precision, this deliberate approach inadvertently overlooked alternative document types such as conference papers, book chapters, and review papers, potentially introducing bias into the study's outcomes. Consequently, the paper presents a comprehensive examination of the utilization of EMG, GSR, and ECG tools in neuromarketing activities spanning from 2009 to 2022, drawing insights from the scrutiny of analyzed publications.

6.2 Future agendas

The future landscape of neurophysiological monitoring in marketing envisions groundbreaking applications of Galvanic Skin Response (GSR), Electromyography (EMG), and Electrocardiogram (ECG) technologies. GSR is anticipated to spearhead immersive marketing experiences, particularly in virtual and augmented reality, offering marketers detailed insights into consumer emotions. The envisaged future involves the dynamic optimization of content in real-time using GSR, ensuring continuous alignment with desired emotional impacts.

In the realm of EMG, the trajectory points toward revolutionizing e-commerce by integrating sensors into online platforms. This integration will give marketers real-time insights into facial expressions and muscle activity, shaping a more personalized and emotionally intelligent online shopping environment. Furthermore, EMG is anticipated to lead the way in interactive advertising, where technology embedded in displays allows consumers to engage with content in novel ways, providing marketers with enhanced data on consumer preferences and emotional responses.

Across these technologies, ethical and privacy considerations stand as pivotal themes. As neurophysiological monitoring advances, establishing robust ethical frameworks becomes imperative to ensure the responsible use of consumer physiological data. Interdisciplinary collaboration between marketers, neuroscientists, and technologists is foreseen as vital for

driving innovation, ensuring ethical practices, and navigating the dynamic landscape of neurophysiological monitoring in future marketing strategies.

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