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Traces of TOGG's social media ads in the brain: A neuromarketing study with EEG

TOGG'un sosyal medya reklamlarının beyindeki izleri: EEG ile bir nöropazarlama araştırması

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Abstract

One of the main goals of marketing communication research is to assess communication effectiveness. Although neuroscience methods are gaining popularity for providing more objective insights than traditional approaches, neuromarketing studies on advertising effectiveness and consumer cognition remain limited. Thus, there is a growing need for neuroscience-based research to better understand how social media ads impact consumer cognition. This study conducted a neuromarketing experiment using electroencephalography to measure the physiological effects of social media ads on the brain. Within the Elaboration Likelihood Model framework, participants' brain waves were recorded while viewing selected ads, and their cognitive processes were analyzed. The study offers three key contributions. First, it examines the brain waves that consumers cannot consciously control, revealing the links between ad effectiveness, product preference, and memorability. Second, it compares the neural data of low- and high-involvement consumers to determine more effective persuasion routes. Third, this paper represents one of the first neuromarketing studies to examine the cognitive impact of advertisements for TOGG, Türkiye's first domestic automobile brand, thereby contributing to strategic marketing efforts. The findings of this study provide insights for brands to optimize their advertising strategies based on brain-based data and to enhance consumers' positive brand experiences.

Öz

Pazarlama iletişimi araştırmalarının temel amaçlarından biri, iletişimin etkinliğini ölçmektir. Geleneksel araştırma yöntemlerine kıyasla daha objektif bulgular elde etmede nörobilimsel yöntemlerin artan popüleritesine rağmen, reklam etkinliği ve tüketicilerin zihni üzerine yapılan nöropazarlama çalışmaları hala sınırlıdır. Bu nedenle, sosyal medya reklamlarının tüketici zihnindeki etkilerinin daha iyi anlaşılması için nörobilim temelli kanıtlar sunan araştırmalara duyulan ihtiyaç artmaktadır. Bu çalışmada, sosyal medya reklamlarının beyin üzerindeki fizyolojik etkileri elektroensefalografi ile ölçülerek bir nöropazarlama deneyi gerçekleştirilmiştir. Detaylandırma Olasılığı Modeli çerçevesinde, katılımcıların belirlenen sosyal medya reklamlarını izlerken beyin dalgaları kaydedilmiş ve bilişsel süreçleri ayrıntılı olarak analiz edilmiştir. Çalışma, üç ana katkı sunmaktadır. İlk olarak, tüketicilerin sosyal medya reklamlarını izlerken bilinçli olarak kontrol edemedikleri beyin dalgaları incelenmiştir. Bu sayede, sosyal medya reklam etkinliği ile beyin fizyolojisi arasındaki bağlantılar keşfedilerek ürün beğenisi ve hatırlanabilirliğiyle ilgili zihinsel süreçler daha iyi anlaşılmaktadır. İkinci olarak araştırma, düşük ve yüksek ilgilenimli tüketicilerin sinirsel verilerini karşılaştırarak, hangi ikna yollarının daha etkili olduğunu ortaya koymaktadır. Üçüncü olarak, bu makale Türkiye'nin ilk yerli otomobil markası TOGG'un reklamlarının tüketici zihnindeki etkilerinin incelendiği ilk nöropazarlama araştırmalarından biri olarak stratejik pazarlama çabalarına ışık tutmaktadır. Çalışmanın bulguları, markaların reklam stratejilerini beyin temelli verilere dayanarak optimize etmelerine ve tüketicilerin olumlu marka deneyimlerini güçlendirmelerine yönelik öneriler sunmaktadır.



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Traces of TOGG's social media ads in the brain: A neuromarketing study with EEG

One of the primary objectives of marketing communication research is to assess the effectiveness of communication strategies (Gountas et al., 2019). In recent years, there has been a growing shift among researchers toward mixed-method approaches that integrate qualitative and quantitative research methodologies, with the aim of gaining a more comprehensive understanding of how advertisements—one of the most influential communication tools—affect consumers cognitively, emotionally, and behaviorally (e.g., Kwak et al., 2023; Bakr et al., 2019; Strebing et al., 2018). However, as noted by Gountas et al. (2019), these methods have inherent limitations and share significant biases, which may restrict the ability to obtain complete and accurate insights into consumer thought processes. For instance, although qualitative methods such as focus groups, observations, and interviews are valuable for exploring consumers' deep-seated opinions, attitudes, and value judgments, they inherently rely on self-reports, making the findings subjective. This subjectivity, in turn, limits the impartial interpretation of results and constrains their applicability to broader contexts or potential causal relationships (Majid & Vanstone, 2018). Conversely, while quantitative research methodologies often ensure greater representativeness of the overall population in terms of sampling, the nature of data collection techniques may lead participants to provide socially desirable responses rather than their genuine perspectives, potentially leading to response bias (Gurgu et al., 2020). In this regard, the need for more objective, transparent, and in-depth insights into the effects of advertising messages, their acceptance or rejection levels, and consumers' decision-making processes has remained a focal point of interest for scholars and marketers alike for decades (Gountas et al., 2019; Yen & Chiang, 2021a).

As a pivotal element of brands' strategic communication efforts, social media advertisements are widely recognized as a highly influential tool, offering a broader reach and greater impact than traditional communication channels (Mulcahy et al., 2024). However, measuring the effectiveness of advertisements in social media—an inherently interactive, rapidly evolving, and highly immersive environment—presents substantial challenges for advertising and consumer researchers (Carlson et al., 2022). Recognizing these challenges, marketing research theorists in the early 2000s pointed out neuroscience techniques as a means to uncover consumer insights beyond the scope of traditional methods, thereby opening new avenues for marketing research (Casado-Aranda et al., 2023). Indeed, over the past decade, neuroscience methodologies have been increasingly integrated into marketing studies, providing a compelling framework for decoding the complexities underlying consumer behavior (Ouzir et al., 2024; Sebastian, 2014). Nevertheless, as an emerging and evolving field, consumer neuroscience has yet to reach full theoretical and empirical maturity. There remains a critical need for neuroscience-driven research that offers robust empirical evidence on the cognitive effects of social media advertisements (Wang & Doong, 2017; Vences et al., 2020).

This study is a neuromarketing research focusing on the effects of social media advertisements on consumers' brain activity, drawing upon Petty & Cacioppo's (1984) Elaboration Likelihood Model (ELM) as its theoretical foundation. ELM not only provides researchers with new opportunities to examine the depth of advertising processing and the specific brain regions activated but also offers marketers profound insights for developing more effective advertising strategies (Srivastava & Saini, 2022). According to ELM, persuasion may be induced through a central and peripheral route, depending on the type of information processed by

consumers (e.g., strong arguments versus simple cues) (Shahab et al., 2021). In this regard, neuromarketing integrates neuroscience with consumer behavior, linking the distinct stimuli proposed by ELM to consumer attitudes and decision-making processes (Yen & Chiang, 2021b).

Within this framework, the primary aim of this study was to explore the physiological effects of social media advertisements, supported by various stimuli, on the brain by considering consumers' high and low attitudes toward the product category. This approach enables a more comprehensive analysis and understanding of consumer behavior. Since numerous studies have examined neuronal signals that occur without direct intervention, research has demonstrated the advantages of utilizing EEG as a tool for understanding different cognitive and emotional states (Yen & Chiang, 2021a; Ciorciari et al., 2019). EEG captures current signals from active neurons in the brain through sensors placed on the scalp of individuals exposed to advertisements. By analyzing the location and intensity of brain waves, it is possible to obtain cognitive and behavioral insights within milliseconds following changes in brain activity (Wajid et al., 2021). In essence, regional brain activity involves the activation of neurons in response to various psychological and behavioral processes, and EEG facilitates the acquisition of new insights into consumer decision-making processes by measuring these signals (Bazzani et al., 2020; Ciorciari et al., 2019). Based on these advantages, this study employs EEG to measure the neuronal signals of participants exposed to advertisements.

Since consumer neuroscience remains an evolving field, only a limited number of studies have examined neural (cognitive and emotional) data concerning both the intensity of advertising stimuli and the level of consumer engagement with advertisements. Unlike previous studies focusing primarily on the effects of advertisements on brain activity, this study investigates two distinct advertisements of a brand—one in print media and the other in social media—each varying in stimulus intensity. It further analyzes individuals' neural responses in the context of product preference and the recallability of product model names. Additionally, the study examines changes in electroencephalography (EEG) wave patterns based on participants' high and low involvement levels with the advertised technological product.

This study offers three key contributions. First, it explores brainwave activity that consumers cannot consciously control or deliberately manipulate while viewing social media advertisements. By establishing a link between social media ad effectiveness and brain physiology, the study uncovers the neural mechanisms underlying product preference and recall, providing valuable insights into the cognitive processes involved. These findings contribute to the growing consumer neuroscience literature while also offering marketers deeper insights, as they do not rely on explicit or consciously mediated responses from participants, thereby enhancing objectivity (Alsharif et al., 2021). Second, this research compares the neural data of individuals with low and high involvement levels by considering their pre-existing attitudes toward the product category before exposure to advertisements. In doing so, it provides new empirical evidence in the consumer neuroscience literature, particularly from the perspective of advertising effectiveness and ELM. Third, this study is among the first neuromarketing experiments to examine the cognitive effects of advertisements for TOGG, Türkiye's first domestic automobile brand, using varying advertising stimuli. Unlike previous studies that primarily focus on advertisement perception (e.g., Yılmaz, 2023; Toksarı & Demirbağ, 2024), this research not only investigates consumers' perceptions of advertisements but also conducts an in-depth analysis of brainwave activity and cognitive processes, thereby providing a more comprehensive understanding of how TOGG's marketing strategies can be optimized for consumer engagement.

Theoretical framework

In a business environment where speed and flexibility are critical for gaining a competitive advantage, companies are increasingly turning to online platforms to introduce their products and brand information to potential customers (Li et al., 2022). However, as social media advertising has become more prevalent,

marketers have encountered new challenges, including: (i) how to effectively utilize social media for ad placement, (ii) how consumers respond to social media advertisements, and (iii) how these responses should be assessed (Sreejesh et al., 2020). At this point, various theories concerning consumer perceptions and attitudes toward advertising messages have gained significance, with particular attention given to studies integrating the ELM and social media advertising (Chiu, 2022; Ayar-Senturk et al., 2019).

ELM is a dual-process theory in social psychology that explains how persuasive messages are processed and is widely applied in the field of marketing (Srivastava & Saini, 2022). Elaboration refers to the extent to which individuals engage in thinking about a given topic. Referring to this level of elaboration, Petty & Cacioppo (1984) identified two distinct routes through which persuasion occurs: the central route and the peripheral route. The central route involves high levels of cognitive processing, where recipients carefully evaluate the content of a persuasive message. In this route, consumers who exhibit high involvement with the message exert greater cognitive effort to thoroughly process the information. In contrast, the peripheral route relies more on cues rather than content and is more appealing to consumers with low involvement. Since low-involvement consumers are less motivated to scrutinize the message in detail, they may be reluctant to analyze its content and instead rely on heuristic cues to form attitudes. These cues include elements such as colors, animations, and music embedded within the persuasive message (Petty & Cacioppo, 1984).

Existing research has predominantly employed qualitative methods such as interviews, focus groups, and surveys to assess the persuasive power of social media advertisements and consumer attention toward ads. However, the relationship between advertising effectiveness and the human mind has become an increasingly compelling research subject. Although neuroscience methods have been theoretically proven to possess high predictive power, the full potential of neuromarketing research has yet to be realized, and further studies have been recommended as a future research direction (Constantinescu et al., 2019; Daugherty et al., 2016; Lim, 2018). Consequently, recent studies have shifted toward exploring the relationship between ELM and social media advertising effectiveness from a neuroscientific perspective (Yen & Chiang, 2021b; Hamelin et al., 2020). Given its ability to measure how consumers process embedded advertising messages, their approach or avoidance responses, recall levels, and attitudinal shifts toward behavioral changes, neuromarketing provides valuable insights into the "black box" of the consumer mind, offering a deeper and more transparent understanding (Bettiga et al., 2017; Lim, 2018).

This study examines advertising effectiveness in terms of product model preference and model name recall. Accordingly, an EEG device, an effective measurement tool for creating more impactful messages that activate long-term memory and foster a positive attitude toward advertised products and brands, is utilized (Ouzir et al., 2024). To analyze consumers' brain activity in response to pre-prepared marketing stimuli (central or peripheral), changes in EEG brain signals and the main spectral bands—Delta (0-4 Hz), Theta (3-7 Hz), Alpha (8-12 Hz), Beta (13-30 Hz), and Gamma (30-40 Hz)—are observed (Kawasaki & Yamaguchi, 2012; Mostafa, 2012). The primary objective of such neuromarketing research is to identify subtle changes in stimuli that could have significant effects on marketing effectiveness (Ohme et al., 2010). Second, it aims to explain how variations in the depiction or presentation of different levels of marketing information influence the brain's response patterns (changes in brain signals). For example, Wang & Doong (2017) demonstrated differences in attention levels toward humorous and non-humorous social media advertisements through EEG-measured brain activity. Similarly, Ciorciari et al. (2019) compared the cognitive activities of individuals with varying emotional processing abilities in response to social media marketing campaigns using EEG measurements. Yen and Chieng (2021a) found that central cues, in the absence of peripheral cues, activated the fusiform gyrus and frontal cortex, as measured by EEG. Furthermore, Kenning and Plassmann (2008) emphasized that EEG-derived data provide insights into preference formation and decision-making processes.

This study uses a neuroscientific approach to investigate which regions of the human brain are activated by advertising stimuli to enhance advertising effectiveness. Since advertising effectiveness is examined in terms of product preference and brand name recall, based on the ELM, a low-arousal print advertisement and a high-arousal social media advertisement for the TOGG brand are analyzed. The results of product preference and name recall following the exposure to both advertisements are compared, and the findings are substantiated from a neuroscientific perspective. Within this framework, EEG measurements are used to determine which brain regions are activated by advertising stimuli, influencing product preference and recall, thereby contributing to a deeper understanding of the connection between advertisements and the human mind. Additionally, neuronal responses were compared between the two groups differentiated by their attitudes toward electric vehicles. In this way, the persuasive power of social media advertisements on consumers with high and low levels of involvement is also explored.

Aim and methodology

This part of the study outlines the overall aim of the study and presents the specific objectives and research questions derived from the theoretical framework. It then provides a detailed explanation of the methodological procedure adopted throughout the research.

Aim

Grounded in the ELM, this neuromarketing study aimed to examine the physiological effects of social media advertisements on brain activity by analyzing participants' neural responses to stimuli with varying intensities. Using EEG measurements, the study investigated the relationship between product preference, brand recall, and participants' attitudes toward electric vehicles.

To achieve this aim, the study pursues the following specific objectives:

1. To compare participants' preferences for the advertised products in print and social media advertisements.
2. To compare the brand name recall of the advertised products in print and social media advertisements.
3. To measure the physiological effects of social media advertisements on the brain.
4. To compare the measured brainwave activity between the groups with low and high attitudes toward electric vehicles.

Based on these objectives, this study addresses the following research questions:

RQ1: How do consumers' preferences for the advertised products differ between print and social media advertisements?

RQ2: How does model name recall of the advertised products compare between print and social media advertisements?

RQ3: What are the physiological effects of social media advertisements on brain activity?

RQ4: How does brainwave activity differ between individuals with low and high attitudes toward electric vehicles?

Method

To investigate the neural mechanisms underlying consumers' responses to social media advertisements, this study adopts an experimental neuromarketing design grounded in the ELM (Petty & Cacioppo, 1984). In line with previous research emphasizing the value of EEG in capturing immediate cognitive and emotional reactions (Yen & Chiang, 2021a; Ciorciari et al., 2019), EEG is used here to observe how participants process

advertising stimuli at the neural level. This approach offers a meaningful way to examine the depth and nature of persuasion, especially by considering differences in consumers' involvement and attitudes (Shahab et al., 2021; Wajid et al., 2021).

Sample

Wongtadat (2019) emphasized that participants must meet specific requirements to avoid factors other than "expected stimuli" that could introduce bias in brain responses. Studies utilizing neuroscience imaging techniques tend to involve a smaller number of research participants. Additionally, it is highlighted that participants should be between the ages of 18 and 43. In this study, participants were selected following these recommendations, as done by Cuesta et al. (2018), Meyerding & Mehlhose (2020), and Pileliene & Grigaliunaite (2017). Specifically, when determining the sample size, the argument was considered that in EEG studies, a sample of at least 30 participants allows for results to be obtained with a 1% margin of error (Batı & Erdem, 2016). Accordingly, after ensuring that all criteria were met, the study was conducted with 30 participants ($n = 30$), aged between 18 and 25.

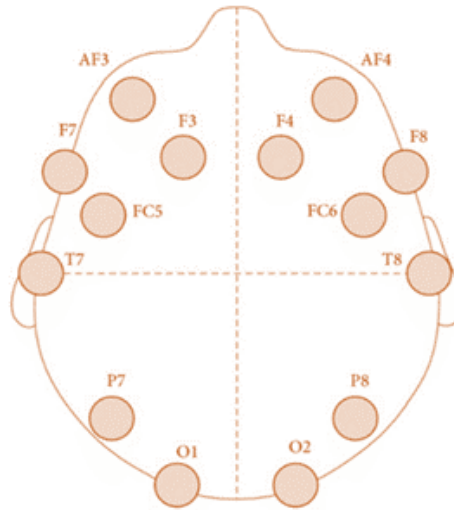
In the selection of participants, the criteria recommended by Bastiaansen et al. (2018) and Hsu & Chen (2019) for studies on brain activity were taken into consideration. Accordingly, all participants met the following conditions: (i) they were at least 18 years old; (ii) they had normal physical and mental conditions; (iii) they had no history of major head trauma, brain tumors, or other neurological disorders; and (iv) they had no history of significant organ diseases. Additionally, participants had not used therapeutic drugs in the past 3 months and had no prior involvement in research related to brain waves. They were informed in advance about the importance of having sufficient sleep and refraining from consuming alcohol or caffeinated beverages (e.g., coffee, tea, chocolate, cola, etc.) before the experiment. Compliance with these conditions was verified before the study commenced.

Prior to the experimental study, the participants responded to five questions adapted from Rezvani et al. (2018) to assess their level of interest in electric cars. Based on their responses, they were categorized into two groups: low involvement ($n = 17$) and high involvement ($n = 13$).

EEG measurement instrumentation

The EMOTIV EPOC device, a 14-channel, high-resolution, wireless headset, was used to monitor and process the EEG data. Numerous studies have demonstrated the effectiveness of this device as a real-time brain EEG scanner (Khushaba et al., 2013). The electrodes of the device were positioned according to the international 10-20 system, creating symmetrical channels. Specifically, the electrodes were placed at AF3 (leftmost anterior frontal), F7 (leftmost frontal), F3 (left frontal), FC5 (left fronto-central), T7 (left temporal), P7 (left parietal), O1 (left occipital), O2 (right occipital), P8 (right parietal), T8 (right temporal), FC6 (right fronto-central), F4 (right frontal), F8 (rightmost frontal), and AF4 (rightmost anterior frontal) (Figure 1). Two additional electrodes (CMS/DRL), located just above the participants' ears, serve as reference points—one for the left hemisphere and the other for the right hemisphere. To ensure effective measurement, all felt pads on the sensors must be moistened with a saline solution before use.

Figure 1
Electrode Positions



Source: Yen & Chiang, 2021a

The EMOTIV EPOC samples data at a frequency of 2048 Hz, which is later downsampled to 128 Hz per channel and transmitted to a computer via Bluetooth. A dedicated USB device is used to establish communication between the computer and the headset. As a whole, the Emotiv Software Development Kit provides several key functionalities: packet count functionality to prevent data loss, a writable marker trace to facilitate single-trial segmentation tasks, and a real-time sensor contact quality display to ensure measurement accuracy.

Stimulus and control

In the study, a low-stimulus print advertisement and a high-stimulus social media advertisement were utilized. For the creation of the print advertisement, images of the TOGG T10X model shared by the brand were used. Six different car images in various colors were combined into a single visual, ensuring that each car was of equal size and randomly numbered. A plain, solid background was used, displaying only the car images and their respective names. Adobe Photoshop was employed in the design of this print advertisement stimulus.

For the social media advertisement, an official video commercial published on TOGG's *YouTube* channel ("Which is your favorite #Togg color?") was selected. This video advertisement lasts approximately 60 seconds and features dynamic animations, vibrant colors, and an energetic soundtrack. Additionally, it provides visual cues regarding the car's design and features.

A pretest was conducted with 25 participants to validate the stimuli. Participants were presented with five statements adapted from the scale used by Chang et al. (2015) and Ayar Sentürk et al. (2019). These statements were designed to assess the effectiveness of the central and peripheral stimuli. After viewing both the print and social media advertisements, the participants were asked to rate each advertisement on a scale from 1 to 10 based on the given statements. The results confirmed the effectiveness of the print advertisement ($M = 23.2$) and the social media advertisement ($M = 40.3$) in terms of central and peripheral stimulus engagement.

Measurement

The study was initiated in accordance with scientific research and publication ethics, following the approval of the Ethics Committee for Social and Human Sciences Research at Yıldız Technical University (Approval

No: 2022.12, dated December 27, 2022). Participants were first shown the print advertisement and given 15 seconds to examine it. Subsequently, they were provided with a form and asked to rank the cars that featured the same model but in different colors, based on their preferences. Additionally, they were instructed to write down the corresponding color names (Anadolu, Gemlik, Oltu, Kula, Kapadokya, and Pamukkale) next to their rankings. It was explicitly stated that they should leave blank spaces for any color names they could not recall. In the next phase, participants were equipped with the Emotiv-Epoc wireless EEG device and were shown the social media advertisement while their brain waves were recorded. Finally, after the video ended, the EEG device was removed, and the participants were once again asked to rank the six different-colored TOGG T10X models from most to least preferred. They were also reminded to write down the color names they could recall, leaving blank spaces for those they could not remember.

Findings

This part of the study presents EEG findings that show how participants' neural responses differ based on various advertising stimuli and their attitudes toward the product category.

Preference and recall

The findings regarding the participants' preference rankings and recall accuracy for the six different TOGG T10X model colors are presented in Table 1. The results indicate that the preference order of the 14 participants shifted following exposure to social media advertisements. Despite this shift, Oltu Black remained the most preferred color across both advertising conditions, followed by Gemlik Blue as the second most favored option. Furthermore, after viewing the print advertisement, 15 participants correctly recalled the color names of their preferred models, yielding a total of 37 accurate model-color pairings. In contrast, following exposure to the social media advertisement, only one participant failed to make a correct pairing, while 29 participants successfully identified the correct model-color associations, resulting in a cumulative total of 127 accurate pairings.

Regarding recall accuracy at the individual level, after the print advertisement, one participant correctly matched all six models, while another correctly matched four models. Additionally, six participants correctly identified three models, two participants recalled two models, and five participants were able to recall only one model accurately. In contrast, after exposure to the social media advertisement, eight participants correctly matched all six models, two participants identified five models, fourteen participants recalled four models, and four participants accurately matched three models. The findings regarding the participants' preference rankings and recall accuracy for the six different TOGG T10X model colors are presented in Table 1. The results indicate that the preference order of the 14 participants shifted following exposure to social media advertisements. Despite this shift, Oltu Black remained the most preferred color across both advertising conditions, followed by Gemlik Blue as the second most favored option. Furthermore, after viewing the print advertisement, 15 participants correctly recalled the color names of their preferred models, yielding a total of 37 accurate model-color pairings. In contrast, following exposure to the social media advertisement, only one participant failed to make a correct pairing, while 29 participants successfully identified the correct model-color associations, resulting in a cumulative total of 127 accurate pairings.

Table 1*Preference rankings and recall after print and social media advertisements*

Participants	After print advertisements		After social media advertisements	
	Preference rankings	Correctly matched product names by color	Preference rankings	Correctly matched product names by color
1	2-3-5-4-1-6	-	2-3-5-4-1-6	Oltu-Gemlik-Anadolu
2	3-2-4-5-1-6	Oltu-Gemlik-Anadolu	3-2-4-5-6-1	Oltu-Kula-Gemlik-Kapadokya-Pamukkale-Anadolu
3	4-5-1-2-3-6	Gemlik-Kapadokya-Anadolu-Kula-Oltu-Pamukkale	4-5-1-2-6-3	Gemlik-Kapadokya-Anadolu-Kula-Pamukkale-Oltu
4	1-5-4-2-3-6	Anadolu-Gemlik	1-5-4-2-3-6	Anadolu-Gemlik-Oltu
5	3-4-1-5-2-6	-	3-4-1-5-2-6	Gemlik-Anadolu-Kapadokya-Pamukkale
6	4-3-6-1-2-5	Oltu-Pamukkale-Anadolu	4-3-6-1-2-5	Gemlik-Oltu-Pamukkale-Anadolu
7	1-4-6-3-2-5	Anadolu-Gemlik-Pamukkale	1-4-6-3-2-5	Anadolu-Gemlik-Pamukkale-Oltu-Kapadokya
8	2-3-5-6-4-1	-	2-3-5-6-4-1	Pamukkale-Anadolu
9	2-3-1-6-4-5	-	2-4-5-3-1-6	Gemlik-Oltu-Pamukkale
10	3-2-6-4-5-1	Anadolu	3-2-4-6-5-1	Oltu-Gemlik-Anadolu
11	4-3-2-6-5-1	Gemlik-Kapadokya-Anadolu	4-3-2-6-5-1	Gemlik-Kapadokya-Anadolu-Kula-Pamukkale-Oltu
12	3-6-4-2-5-1	Oltu-Pamukkale	3-4-2-6-5-1	Oltu-Gemlik-Pamukkale-Anadolu
13	3-2-4-6-1-5	-	3-4-2-6-1-5	Oltu-Gemlik-Kula-Pamukkale-Anadolu-Kapadokya
14	5-4-3-2-1-6	Kapadokya-Gemlik-Pamukkale	5-4-3-2-1-6	Kapadokya-Gemlik-Oltu-Kula-Anadolu-Pamukkale
15	2-5-4-6-3-1	-	2-5-4-6-3-1	Kapadokya-Pamukkale-Oltu-Anadolu
16	4-5-3-2-6-1	-	4-5-3-2-6-1	Gemlik-Oltu-Pamukkale-Anadolu
17	4-5-6-1-3-2	Pamukkale	5-4-2-1-3-6	Gemlik-Anadolu-Oltu-Pamukkale
18	6-2-1-3-4-5	-	1-4-3-6-2-5	Anadolu-Gemlik-Oltu-Kapadokya
19	4-3-1-2-5-6	Gemlik-Oltu-Pamukkale	4-3-1-5-2-6	Gemlik-Oltu-Anadolu-Kapadokya-Pamukkale
20	5-4-2-3-1-6	-	5-4-2-3-1-6	Kapadokya-Gemlik-Anadolu-Pamukkale
21	5-6-2-3-1-4	Pamukkale	5-6-2-3-1-4	Pamukkale-Oltu-Anadolu-Gemlik
22	5-4-2-3-6-1	-	5-3-4-2-6-1	Kapadokya-Oltu-Gemlik-Kula-Pamukkale-Anadolu
23	2-5-3-4-6-1	Kapadokya	2-5-3-6-4-1	Kula-Kapadokya-Oltu-Pamukkale-Gemlik-Anadolu
24	1-6-3-5-2-4	-	1-5-2-6-3-4	Anadolu-Kapadokya-Kula-Pamukkale-Oltu-Gemlik

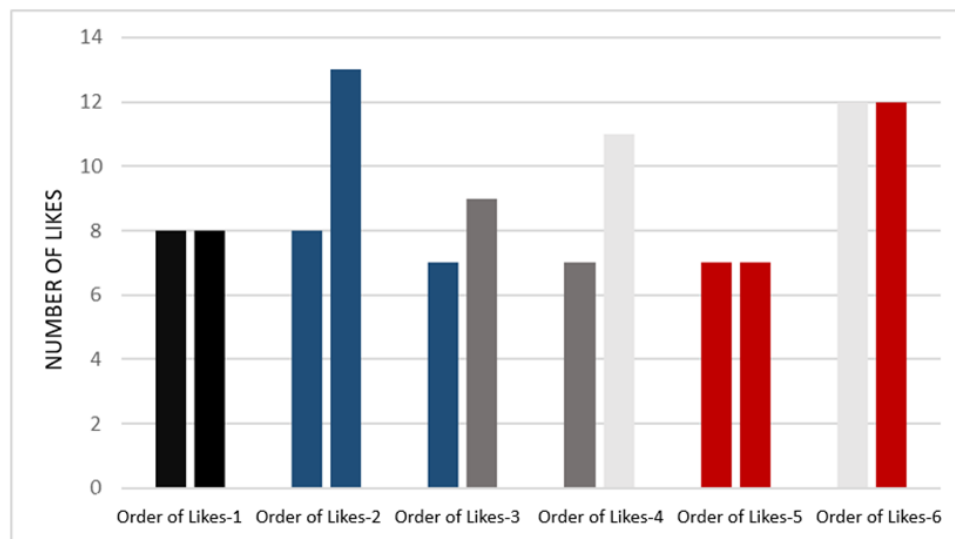
After print advertisements			After social media advertisements	
25	2-4-3-1-5-6	-	2-4-1-3-5-6	Gemlik-Anadolu-Oltu-Pamukkale
26	4-1-5-3-2-6	-	4-1-3-2-5-6	-
27	3-2-4-1-5-6	Gemlik	3-4-2-6-5-1	Oltu-Gemlik-Pamukkale-Anadolu
28	5-3-4-2-6-1	-	5-3-4-2-6-1	Kapadokya-Oltu-Gemlik-Anadolu
29	3-4-5-6-2-1	Oltu-Gemlik-Pamukkale-Anadolu	3-4-5-6-2-1	Oltu-Gemlik-Pamukkale-Anadolu
30	3-4-2-5-1-6	-	3-4-2-5-1-6	Gemlik-Kapadokya-Anadolu-Pamukkale

Figure 2 presents a comparative analysis of the most preferred models after exposure to print and social media advertisements. Similarly, Figure 3 compares the recall rates for each product name under these two advertising conditions. The findings indicate that while name recall was relatively low after the print advertisement, recall rates increased for each model following exposure to the social media advertisement. After viewing the print advertisement, the Anadolu model was correctly identified by 8 participants, the Kula model by 1 participant, the Oltu model by 6 participants, the Gemlik and Pamukkale models by 9 participants, and the Kapadokya model by 4 participants. Among these, Gemlik and Pamukkale had the highest recall rates, whereas Kula had the lowest recall rate.

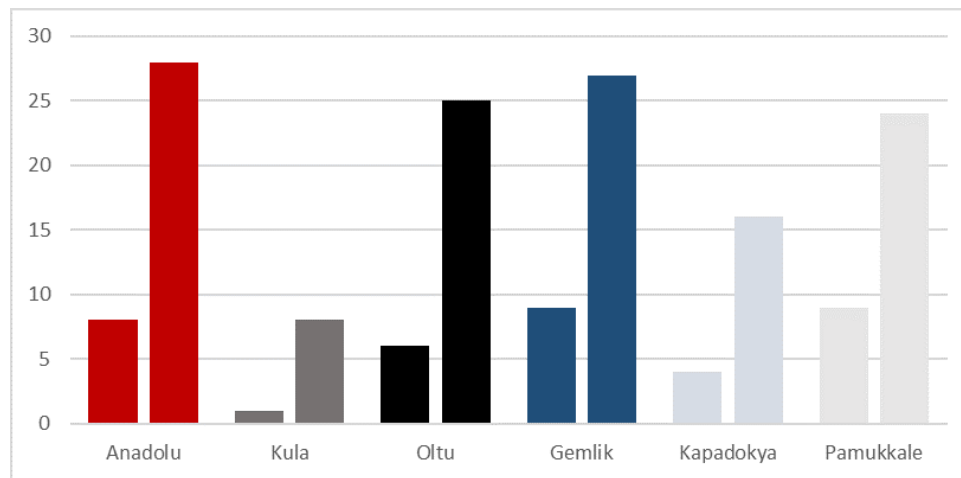
In contrast, following the social media advertisement, 28 participants correctly identified the Anadolu model, 8 identified the Kula model, 25 identified the Oltu model, 27 identified the Gemlik model, 16 identified the Kapadokya model, and 25 identified the Pamukkale model. In this case, Anadolu emerged as the most accurately recalled model name, whereas Kula remained the least recalled. Furthermore, the accuracy rate for correctly recalling color names before exposure to the advertisement was 20.5%, whereas this rate increased to 72.2% following the social media advertisement.

Figure 2

Preference ranking after print and social media advertisements



Left Column: Print advertisement **Right Column:** Social media advertisement **Black:** Oltu, **Blue:** Gemlik, **Gray:** Kula, **White:** Pamukkale, **Red:** Anadolu

Figure 3*Recall after print and social media advertisements*

Left column: After print advertisement, Right column: After social media advertisement

EEG-based neural activation

After confirming the differentiation in preference rankings and product name recall following exposure to print and social media advertisements, the next step involved exploring the cognitive processes underlying these changes. As stated in the measurement process section, the participants' brain activity was recorded using the Emotiv-Epoc device while they viewed social media advertisements. The signals captured during the presentation of the images were processed using Excel to examine the relevant associations. Measurement maps of the participants' brain activity are presented in Appendix 1.

Analysis of brain activity revealed that the highest activation was observed in the F4 (right frontal) region, followed by the FC6 (right frontal-central), AF4 (right anterior frontal), and F8 (far-right frontal) regions. The right hemisphere, where brain waves reach high microvolt (μV) values, serves as the command center for artistic activities such as music, color, and design, which involve visual and auditory imagery. This hemisphere is associated with art, music, inspiration, and creativity, indicating that the impact of centrally and peripherally placed visual and auditory cues in advertisements can be explained by fluctuations in these regions. Furthermore, the fact that the highest activation within the right hemisphere occurred in the frontal lobe is particularly noteworthy. Examination of the EEG data showed that the frontal region exhibited higher μV values, indicating greater electrical activity and intensity. The frontal lobe's activity is critical in marketing research, as advertising effectiveness, emotional responses, decision-making processes, and consumer preferences are analyzed by assessing activity in this area. The prefrontal cortex (AF4), which exhibited high electrical activity, was linked to higher-order consciousness. Therefore, it can be inferred that the persuasive cues in the social media advertisements were consciously processed by the participants, facilitating learning through synthesis and evaluation.

It was observed that seven participants (Participants 1, 6, 7, 11, 13, 24, and 29) exhibited activation in the range of 4450–4550 μV in the left anterior frontal (AF3), left frontal (F7), left fronto-central (FC5), left temporal (T7), left parietal (P7), left occipital (O1), right occipital (O2), right parietal (P8), and right temporal (T8) regions (Appendix 1 i, vi, vii, xi, xiii, xxiv, xxix). These participants also demonstrated the highest recall accuracy in correctly matching product names after viewing social media advertisements. The temporal region plays an active role in memory processing. While the right temporal lobe is responsible for storing visual memory, the left temporal lobe stores verbal memory. The occipital region houses the visual cortex, which facilitates vision and is responsible for the interpretation of visual stimuli. The parietal region processes sensory

information from various parts of the body and contributes to the interpretation of visual and textual messages in advertisements. The activation of these three regions represents a significant finding in terms of recall enhancement. Because elements of the social media advertisement are initially perceived by the occipital lobe, the processing of sensory signals, as well as the interpretation of shapes and colors, occurs in the parietal lobe. The temporal lobe, which is associated with comprehension and memory storage, encodes the processed signals into visual memory. The high neural activity in the temporal, occipital, and parietal regions indicated that linking car colors in the advertisement to destination-inspired names was an effective strategy. This connection stimulates the senses, enhances memory association, and facilitates encoding into working memory. However, no activation was detected in the F3 region, which represents the left frontal lobe and is primarily involved in language processing, production, speech, and linguistic skills. The absence of fluctuations in this area aligns with expectations, as social media advertisements rely heavily on visual animations and auditory elements rather than linguistic processing.

Comparison of EEG data based on the levels of involvement

Prior to the measurement process, a pretest study was conducted to classify the participants into two groups based on their levels of involvement with electric cars. The comparative analysis of their brain activity is presented in Table 2. For participants with low involvement in electric cars, electrical activity was predominantly observed in the right frontal region, particularly in the right frontal-central, far-right frontal, and rightmost anterior frontal areas, where brain waves reached high microvolt values. EEG-based brainwave graphs indicate that, with the exception of Participants 6 and 30, brain activity in low-involvement participants remained relatively stable within the 4300-4500 μV range. However, in the FC6, F4, F8, and AF4 regions, the brain wave activity increased, reaching values between 4550 and 4700 μV . Notably, the brainwave patterns of Participants 6 and 30 differed from those of other low-involvement participants, displaying additional activity in the left hemisphere, particularly in the AF3, F7, FC5, T7, P7, O1, O2, P8, and T8 regions. This suggests a more fluctuating neural response to the stimulus (Appendix 1vi,xxx).

In contrast, participants with high involvement processed the advertisement with greater cognitive engagement, resulting in observable activity in both the left and right hemispheres of the brain. Brainwave graphs revealed that compared to low-involvement participants, those with high involvement exhibited more dynamic and intense neural activity. This pattern was particularly evident in Participants 3, 7, 11, 13, and 24, whose brainwave graphs strongly supported this observation (Appendix 1iii,vii,xiii,xxiv). These findings suggest that high-involvement participants engaged with the social media advertisement with significantly greater attention and cognitive effort, leading to a more pronounced neural response compared to their low-involvement counterparts.

Table 2

Brain activity regions based on the levels of involvement

	AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
	Low-involvement participants													
P 1											X	X	X	X
P 2												X		
P 6	X	X		X	X	X	X	X	X	X		X		
P 9											X	X	X	X
P 10											X	X	X	X
P 12												X		

	AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
P 14												X		
P 16											X	X		
P 17												X		
P 18											X	X	X	X
P 19												X		
P 21												X		
P 26												X		
P 27												X		
P 28												X		
P 29	X	X		X	X	X	X	X	X	X		X		
P 30												X		
	AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
High Involvement Participants														
P 3	X	X		X	X	X	X	X	X	X		X		
P 4							X				X	X	X	X
P 5											X	X		X
P 7	X	X		X	X	X	X	X	X	X		X		
P 8											X	X	X	X
P 11	X	X		X	X	X	X	X	X	X		X		
P 13	X	X		X	X	X	X	X	X	X		X		
P 15											X	X	X	X
P 20											X	X	X	X
P 22											X	X	X	X
P 23											X	X		
P 24	X	X		X	X	X	X	X	X	X		X		
P 25											X	X		X

Discussion and conclusion

This study aimed to investigate the effectiveness of print and social media advertisements by examining consumer preferences, model name recall, and brain activity through EEG measurements. The findings provide neuroscientific insights into the cognitive and emotional processes underlying advertising effectiveness and offer valuable implications for marketing strategies.

Numerous studies have compared the effectiveness of print, audiovisual, and social media advertisements, demonstrating the significant impact of social media ads on consumer attitudes and behaviors (Kahraman & Kalan, 2024; Lu et al., 2023; Lim et al., 2015). Additionally, studies have explored the role of peripheral and central cues in shaping consumer responses to social media advertisements (Jayawardena et al., 2023). In recent years, neuromarketing research, which integrates neuroscience and consumer behavior, has gained prominence by analyzing the brain's physiological responses to advertisements (Wajid et al., 2021; Yen & Chiang, 2021a). While previous studies have primarily focused on how advertisements influence brain activity, this study extends the literature by examining the effectiveness of print and social media advertisements with varying levels of stimulus intensity. It investigates consumers' neural responses to

social media advertisements in relation to product preference and model name recall. Furthermore, the study explores variations in EEG wave activity based on consumers' levels of involvement with the advertised technological product. By bridging the fields of neuroscience and marketing, this research offers both theoretical contributions to the literature and practical insights for marketers.

In addressing the first research question, the study compared consumer responses to different advertising mediums. The results indicate that social media advertisements exert a stronger influence on product preference than print advertisements. This aligns with prior research suggesting that digital advertising formats, by incorporating both central and peripheral cues, create a more immersive experience that fosters increased consumer engagement (Lu et al., 2023; Lim et al., 2015). The ability of social media ads to integrate interactive and visually stimulating content likely enhances their persuasive impact.

Regarding the second research question, which examined the extent to which advertising format influences memory retention, the findings reveal that social media advertisements significantly improve model name recall. The correct recall rate increased from 20.5% to 72.5% after exposure to social media advertisements, highlighting their superior ability to enhance memory encoding and retrieval. Given that memory recall is closely linked to frontal brain activation, this result suggests that social media advertisements facilitate deeper cognitive processing, thereby strengthening brand and product recall.

The third research question explored how different advertisements influence neural responses. The EEG analysis indicated that social media advertisements activated key brain regions associated with attention, memory, and decision-making, particularly the frontal and prefrontal cortices. These areas are crucial for high-level cognitive functions, including preference formation and recall (Plassmann et al., 2015; Bigne et al., 2024). Moreover, the findings suggest that advertisements incorporating destination-related stimuli further enhance frontal brain activity, supporting the idea that associating products with familiar or emotionally resonant cues improves consumer attention and recall (Kim et al., 2019; Liu et al., 2023). These results provide neuroscientific evidence that familiarity and emotional relevance are key factors in advertising effectiveness.

The fourth research question investigated the role of consumer involvement in moderating neural responses to advertisements. The findings indicate that low-involvement consumers exhibit flatter and less frequent brain waves in the left hemisphere while processing advertisements containing both central and peripheral cues. This suggests that they rely more on peripheral processing, making intuitive and emotionally driven evaluations rather than engaging in detailed cognitive analysis. In contrast, high-involvement consumers displayed heightened neural activity, particularly in the right hemisphere and across the temporal, occipital, and parietal lobes of the left hemisphere. This pattern of activation reflects deeper cognitive engagement with the advertisement content. These findings align with the ELM theory, which posits that high-involvement consumers engage in more elaborate cognitive processing when evaluating advertisements (Gey & Becan, 2024; Yen & Chieng, 2021a). Additionally, participants with stronger neural activation across multiple brain regions performed better in accurately recalling product colors and names, reinforcing the idea that both central and peripheral cues contribute to memory formation and positive brand attitudes.

Beyond its theoretical contributions, this study offers critical managerial implications, particularly for TOGG's strategic promotional efforts. As a visionary brand representing Türkiye's technological advancement, TOGG must leverage its domestic brand identity to establish a strong market presence. The findings indicate that consumers rely on peripheral cues, such as cultural symbols and emotionally resonant imagery, to form an emotional connection with the brand. This highlights the importance of incorporating culturally relevant elements, such as national symbols, music, and metaphors, into advertising campaigns. Further-

more, the study confirms that high-involvement consumers process both the visual and cognitive aspects of advertisements, emphasizing the need to highlight TOGG's technological innovation and leadership in its marketing strategies. Given the growing competition in the mobility sector, TOGG should strategically position itself as an industry leader by emphasizing both emotional engagement and technological excellence in its promotional efforts.

In conclusion, this study provides neuroscientific evidence supporting the superior effectiveness of social media advertisements over print advertisements, demonstrating that social media ads enhance product preference, model name recall, and cognitive engagement. The findings confirm that advertising effectiveness is closely linked to brain activity and that consumer involvement levels significantly influence how advertising stimuli are processed. By integrating insights from neuromarketing research, companies like TOGG can develop more effective advertising strategies that enhance brand recall, consumer engagement, and positive brand attitudes.

Limitations and future research

There are several limitations affecting the generalizability of this study's findings. First, the study is based on a sample of 30 participants. While this sample size falls within an acceptable range for neuromarketing research (Meyerding & Mehlhose, 2020), ensuring the replicability of such studies is crucial for generalizing the results.

In this study, brain activity was measured solely using EEG. Although EEG is an effective technique for investigating advertising effectiveness, future research should consider integrating other neuromarketing methods, such as eye-tracking, functional magnetic resonance imaging, and facial action coding system analysis. Examining the combined and synergistic effects of these techniques could provide a more comprehensive understanding of consumer responses to advertisements.

This study was conducted shortly after the launch of the TOGG brand. Given that the research period coincided with an election cycle, participants were not asked about their political views or attitudes toward the brand. However, since neuromarketing primarily focuses on unconscious mental responses, comparing the reactions of consumers with different political perspectives or pre-existing positive/negative attitudes toward the brand could be an interesting avenue for future research. Additionally, investigating ethnocentric tendencies within the framework of consumer neuroscience would be valuable.

The examination of TOGG from a neuromarketing perspective is of great significance. Future studies could explore the effects of different marketing strategies on consumers' brain activity in greater detail. Such research would be particularly critical in understanding the relationship between digital marketing, social media engagement, and traditional media advertisements in shaping neural responses. Furthermore, investigating the link between TOGG's customer loyalty and satisfaction from a neuromarketing standpoint would be highly beneficial. Studies on how customer loyalty and satisfaction influence brain activity could provide valuable insights into the brand's long-term success.

Additionally, research on how TOGG's vehicle design influences consumers' brain activity and shapes brand perception could offer key contributions to the company's product development strategies. Finally, examining TOGG's impact on market share and competitive dynamics from a neuromarketing perspective would be noteworthy. Comparative studies with competing brands could provide a deeper understanding of TOGG's market position and consumer preferences, offering valuable opportunities for strategic decision-making.



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Appendix | Ek

Appendix 1

EEG-Based Brain Waves

