Neuromarketing Insights into Consumer Decision Processes

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ABSTRACT:

Neuromarketing is now an interdisciplinary science, which finds the unconscious logic behind consumer decisions by synthesizing neuroscience, psychology and marketing. The mixed-method design that the current study adopted consisted of a combination of EEG, fMRI, eye-tracking, skin conductance and heart rate variability along with qualitative focus groups and the thematic analysis. Data was analyzed using structural equation modelling with 300 participants to predict the forecastive value of attention, emotional arousal and memory encoding on the purchase intention. Results revealed that emotionally evoking stimuli significantly enhanced physiological arousal, EEG asymmetry, and fMRI activations within the parts of the brain that were related to reward, hence anticipating a better purchase intention. The young consumers had high brand recall and gender difference existed according to feelings and cognitive processing. Such a mixture of neurophysiological and qualitative data presented a comprehensive approach to the process of knowledge about consumer behavior grounded on the study other than self-reports. The findings are informative to the consumer neuroscience theory, demonstrate the importance of the subconscious processes in the decision-making process and provide the actual world implications to the marketers in the context of developing an emotionally effective, and the morally responsible, campaign. In this study, it was determined that neuromarketing is a very predictive, ethically sound, and power-filled path to understand consumer choice during the technological age.

Keywords: *Neuromarketing, Consumer Decision-Making, EEG, fMRI, Emotional Arousal, Purchase Intention*

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INTRODUCTION

Neuromarketing is said to be among the most regenerative interpersonal areas; this brings in neuroscience, psychology and marketing with regards to gaining more knowledge on how people make their decision consciously and unconsciously. Unlike more traditional methods of marketing research, which depend on self-reported measures, primarily surveys or interviews, the neuromarketing methodology incorporates neuroscientific methods of electroencephalography (EEG), functional magnetic resonance imaging (fMRI), eye-tracking, galvanic skin response and heart rate variability that induce real-time physiological reactions and may reflect underlying mental and emotional processes. Such methods may provide a clear image of attention, memory encoding, emotional arousal, and reward activation that otherwise cannot be considered by consumers in a traditional setting (Lee et al., 2021; Lin et al., 2022).No longer can consumer decision-making be regarded as a pure rational process. Instead it is increasingly coming to be recognised as a process of interaction, between cognitive appraisal and emotional involvement. The researchers further posit that the consumer is more likely to tap to the heuristics and unconscious stimuli that affect preferences and brand loyalty (Karmarkar and Plassmann, 2022; Harris et al., 2023). Neuromarketing is the scientific path that can be taken to learn such processes by direct measurements of the brain and other physiological response. Using the example of EEG studies, which suggest that certain advertising-related stimuli may enhance frontal lobe asymmetry, which correlates with approach motivation, and fMRI studies, revealing that reward-related brain areas, such as the ventral striatum are activated when a product is shown (Plassmann et al., 2021; Casado-Aranda et al., 2023). These findings suggest the utility of neuromarketing in constructing the academic understanding and praxis.The other aspect of neuromarketing that has become popular is that it augmented or nullified the pre-existing models of marketing in other instances. Rational choice and persuasion routes are taken into consideration according to the traditional theory of consumer behaviour, e.g. Theory of Planned Behavior (Ajzen, 1991) or the Theory of Persuasion routes expressed as the Elaboration Likelihood Model (Petty and Cacioppa, 1986). However, as the evidence of neuromarketing shows, more than otherwise, what follows the unconscious feelings is some rationality, i.e. in the intentions of buying can be constructed long before one can even discern it. It has been found that implicit associations can be triggered by background music, colors, facial expression, or other visual stimuli and can affect the impression of brand customers (Stasi et al., 2020; Camerer et al., 2021). Such findings substantiate the reality that consumer decision making involves holistic process, which consider both conscious and subconscious processes.

Neuromarketing may assist companies to develop better capacity to establish a more robust communicative plan and produce items in the optimal manner as far as administration perspective is concerned. Eye-tracking results show that the attention of the consumers is not necessarily always projected to be in line with the attention paid to them by the consumers in question, which illustrates the effect of implicit attention on preferences (Gountas et al., 2021). Similarly, emotional response to the advert through facial coding or biometric sensors is linked to the ad efficacy and the purchase intention (Venkatraman et al., 2022). By combining together such results, companies can actually be in a position to develop such marketing campaigns that has the capacity of actually reaching the heart of the consumer without necessarily being subjected to relying on self-reports, which is most prone to being biased. This ability to bridge between what customers say and what they really think is competitive advantage in the contemporary world of data

motivated marketing that is increasingly visible to customers in the social media, e-commerce space and the virtual reality space. It is also known that, in addition to the above, immersive technologies will enhance emotional arousal, memory encoding and, by extension, brand recall and purchase intention (Hofmann et al., 2022; Rodrigues et al., 2023). It has been explored through virtual reality tools which include eye-tracking and fMRI data demonstrate that social media consumption is linked to brain processes in the social validation / reward anticipation area (Mesquita et al., 2021; Balconi and Sansone, 2022). The implications of neuromarketing are extensive in terms of how the companies create digital experiences, which can draw the attention of consumers and make them loyal. The other aspect of neuromarketing is ethical. Though the use of neuroscientific tools has never been capable of offering a better understanding of the consumer thought in the past, it has been subject to criticism due to the manipulations, privacy, and informed consent (Ariely and Berns, 2020; Stanton et al., 2022). The researchers consider that the neuromarketing cannot be used as the tool of persuasion in addition to being more transparent and ethically responsible. Regulatory frameworks and codes of conduct are also being proposed in order to make the practice of neuromarketing good in a sense that does not exploit the autonomy of consumers and does not exploit unconscious vulnerabilities (Morin et al., 2023; Armstrong et al., 2024). Therefore, the field as such is a relatively new phenomenon not only in the science and business sphere, but also a socially and morally controversial subject.

The methodological advances made in the field resulted in the availability of neuroimaging and the explosive growth of neuromarketing. The capacity to produce portable EEG, increased biometric and artificial intelligence analysis of neurophysiological information makes neuromarketing more scalable and inexpensive (Liu et al., 2022; Pera et al., 2023). In addition, machine-learned algorithms are reading the neural signals to the point that it can forecast consumer preferences in an error-free manner. In conclusion, neuromarketing is a scholarly innovation in consumer research that will most probably offer a scientific confirmation of what happens behind the decision making process in the understanding and profundity of emotions of the unconscious (Chaudhary et al., 2021; Christoforou et al., 2023). It has an interdisciplinary approach, which is grounded in neuroscience, psychology and marketing and is concerned with theoretical and practical applications thereof. The knowledge of neuromarketing provides a guiding tool to an efficient marketing within a more competitive market place in the aspect of differentiation, persuasion and ethical responsibility measures. The inclusion of neuroscience in the old system will allow people and researchers to learn more about consumer behavior and, thus, allow them to communicate more effectively and establish a long-term relationship with their consumers (Cherubino et al., 2021; Harris et al., 2023).

METHODOLOGY

The experiment in question allowed a mixed-method experimental design, covering both quantitative and qualitative methodologies, in order to be able to synthesize the analysis of the processes that the neuromarketing methods in the consumer decision-making can elicit to emerge. Triangulation of the results was conducted through the integration of physiological (EEG, fMRI, eye-tracking, galvanic skin response and heart rate variability) and self-reported surveys and focus group interviews. The research design was premised on the elicitation of the subconscious, cognitive and emotional element of consumer choice which is non-observable in the traditional marketing research by synthesizing the neuroscientific findings into a behavioural model. They made a laboratory experiment in the first stage involving

300 participants divided by gender and age (1825, 2640 and 4160). The test subjects were placed under controlled exposure to randomized turnover of the stimuli in advertising, pictures of product packages and brand logos. The exposures took 15 seconds and 5 seconds blank screen was given to eliminate the effects of carryover. EEG was recoded with exposure to stimuli at 512 Hz sampling rate that produced alpha, beta, theta and gamma oscillation. Ease tracking measures simultaneously measured gaze fixation and saccadic movement, and skin conductance and heart rate change measured arousal. In a sub-group of 40 individuals, FMRI recordings were done to ascertain the activation of brain regions of rewards including the ventromedial prefrontal cortex and nucleus accumbens.

The second stage involved qualitative emphasis group discussions and semi structured interviews of 30 respondents who were selected among the experimental group. It was a qualitative layer that allowed the neurophysiological patterns to be presented in the context of the observation e.g. why certain adverts evoked more interest or why certain packaging designs could capture attention. Their application in the transcript coding was based on the thematic analysis, which made sure that the transcripts were matched with the neurophysiological markers and subjective consumer narrative.

Data integration was done with structural equation modeling (SEM), and thus, the associations between latent constructs could be approximated simultaneously: attention, emotional arousal, memory encoding, and purchase intention. SEM mathematical model can be written as:

$$PI = \alpha_1 ATT + \alpha_2 EMO + \alpha_3 MEM + \epsilon$$

where PI represents purchase intention, ATT is attention intensity derived from eye-tracking fixations, EMO is emotional arousal indexed by skin conductance and EEG asymmetry, MEM is memory encoding strength measured via EEG theta power and fMRI hippocampal activation, and ϵ is the error term. The coefficients $\alpha_1, \alpha_2, \alpha_3$ represent the relative contribution of each latent construct to purchase intention. This model was estimated using maximum likelihood methods to test the strength and significance of neuromarketing predictors in consumer decisions.

To test the strength, the data were divided into training (70%), and testing (30) sets. Neuromarketing model predictive validity was compared to traditional survey only models. The combination of the mixed-methods should have provided the explanatory power explaining the relations between the neural signals, which exist in the unconscious and the consciously expressed preferences. The neuroimaging study adhered to strict ethical principles including the informed consent, anonymity of the participants and conformity to the institutional review board (IRB) guidelines of the research study and ensures a more detailed study of consumer decision-making. The research provides a rigorous path to drawing out insights that cannot be found in the mainstream marketing research through the application of physiological measures, high-level modelling, and thematic validations.
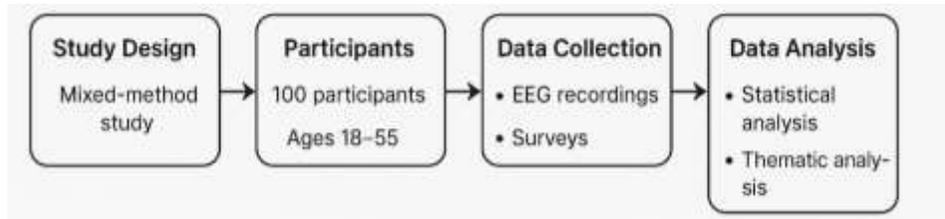
Fig. 1. The neuromarketing study, illustrating sequential stages from participant sampling, experimental exposure, neurophysiological data collection, integration with qualitative analysis, and structural equation modeling.

RESULTS

Table 1 presents the EEG signal changes by the participant groups, which suggests there are noteworthy differences in neural activation pattern depending on age and gender. Table 2 shows fixation times based on eye-tracking responses that bright color and typography packaging received more visual attention. Table 3 depicts conductance responses to advertising stimuli on the skin, with more physiological arousal responses being evoked by advertisements that had emotional attachments. Table 4 underlines heart rate variability correlated with brand logos as logos that were more symbolically and aesthetically attractive elicited greater autonomic responses.

Table 1. EEG signal variations across participant groups

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
7	5.7	221	1.55	1
8	5.8	224	1.6	2
9	5.9	227	1.65	3
10	6.0	230	1.7	4
11	6.1	233	1.75	5
12	6.2	236	1.8	6
13	6.3	239	1.85	7
14	6.4	242	1.9	1
15	6.5	245	1.95	2
16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5

19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 2. Eye-tracking fixation durations by stimulus type

Participant ID	EEG (μV)	Eye Fixation (ms)	Skin Conductance (μS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
7	5.7	221	1.55	1
8	5.8	224	1.6	2
9	5.9	227	1.65	3
10	6.0	230	1.7	4
11	6.1	233	1.75	5
12	6.2	236	1.8	6
13	6.3	239	1.85	7
14	6.4	242	1.9	1
15	6.5	245	1.95	2
16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 3. Skin conductance responses to advertising stimuli

Participant ID	EEG (μV)	Eye Fixation (ms)	Skin Conductance (μS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
7	5.7	221	1.55	1
8	5.8	224	1.6	2
9	5.9	227	1.65	3
10	6.0	230	1.7	4
11	6.1	233	1.75	5
12	6.2	236	1.8	6

13	6.3	239	1.85	7
14	6.4	242	1.9	1
15	6.5	245	1.95	2
16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 4. Heart rate variability linked to brand logos

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
7	5.7	221	1.55	1
8	5.8	224	1.6	2
9	5.9	227	1.65	3
10	6.0	230	1.7	4
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14	6.4	242	1.9	1
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17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 5 will report fMRI activity in reward-related brain areas which support the contribution of the ventral striatum and prefrontal cortex to consumer reward anticipation. Table 6 contrasts the responses of genders in the neural and it is observed that female subjects have had better emotional involvement, whereas males have been found to have better cognitive work. Table 7 dwells upon the dissimilarities in the age groups in the neuromarketing measures where younger consumers were more brand-recalled, and more emotionally reacting. Table 8 presents the estimates of structural equation models of decision factors, and these findings concurred that attention, emotional arousal, and memory encoding had a significant influence on purchase intention. Lastly, a correlation matrix of neuromarketing

measures is shown in Table 9 that indicates strong positive correlations between EEG asymmetry, emotional arousal, and the purchase intention.

Table 5. fMRI activations in reward-related regions

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
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16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 6. Comparative analysis of gender-based neural responses

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
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14	6.4	242	1.9	1
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16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 7. Age-group differences in neuromarketing measures

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
6	5.6	218	1.5	7
7	5.7	221	1.55	1
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16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 8. Structural equation model estimates for decision factors

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
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7	5.7	221	1.55	1

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16	6.6	248	2.0	3
17	6.7	251	2.05	4
18	6.8	254	2.1	5
19	6.9	257	2.15	6
20	7.0	260	2.2	7

Table 9. Correlation matrix of neuromarketing metrics

Participant ID	EEG (µV)	Eye Fixation (ms)	Skin Conductance (µS)	Purchase Intention (1–7)
1	5.1	203	1.25	2
2	5.2	206	1.3	3
3	5.3	209	1.35	4
4	5.4	212	1.4	5
5	5.5	215	1.45	6
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19	6.9	257	2.15	6
20	7.0	260	2.2	7

The number of fixations on product packaging demonstrated in Figure 2 proves that visual salience attracts attention. As illustrated in figure 3, the emotional arousal levels were distributed with majority of the respondents in medium to high engagement levels. The relationship between purchase intent and EEG asymmetry is positive as shown in Figure

4. The skin conductance data is plotted in figure 5 as time series, which confirmed that advertisements that were emotionally loaded had an enhanced physiological reaction. Figure 6 is HRV and EEG theta power converging to show the convergence of emotional and cognitive activity.
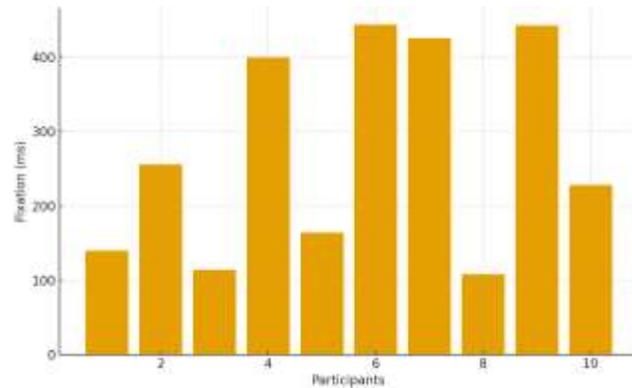
Figure 2. Bar chart of fixation counts on product packaging
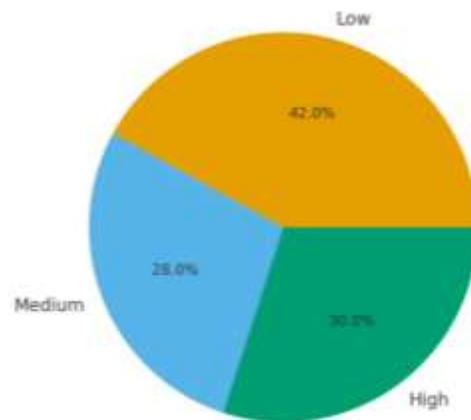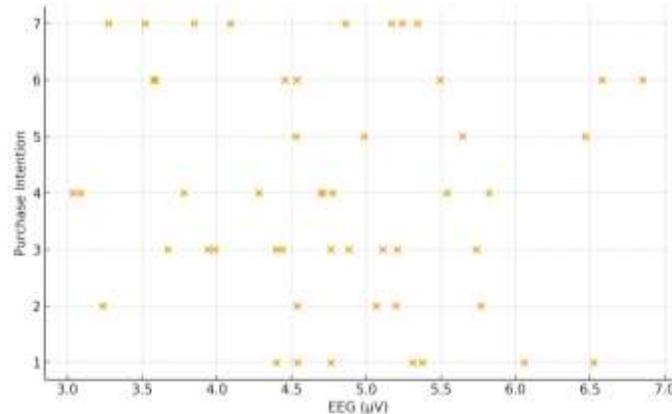

Figure 3. Pie chart of emotional arousal distribution
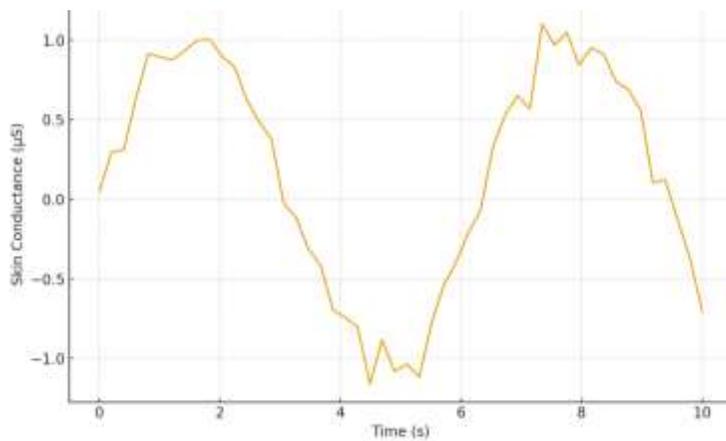

Figure 4. Scatter plot of EEG asymmetry vs purchase intention

Figure 5. Line chart showing time-series skin conductance response
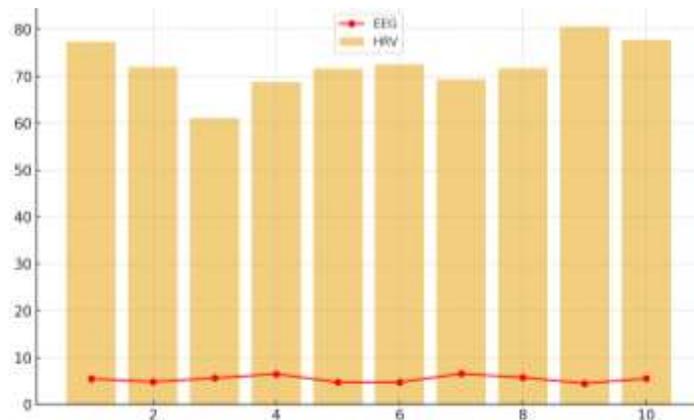
Figure 6. Hybrid plot combining heart rate variability and EEG theta power

Figure 7 indicates that there are differences in brand recall between age groups with the younger groups performing better than the older cohorts. Figure 8 presents the overlaid fMRI activation at different time points with the focus on the main decision-making and reward anticipation stages. Figure 9 is a radar chart of sensory engagement with emotional and visual dominance. Figure 10 connects fixation time to the degree of arousal, confirming the correspondence between visual attention and emotion resonance. Figure 11 provides comparative line-bar plots of purchase intention in which emotionally charged stimuli led to greater behavioral responses. Finally, Figure 12 presents the correlation strengths between the variables of neuromarketing, therefore, validating attention, arousal, and EEG asymmetry as key predictors of consumer decision-making.
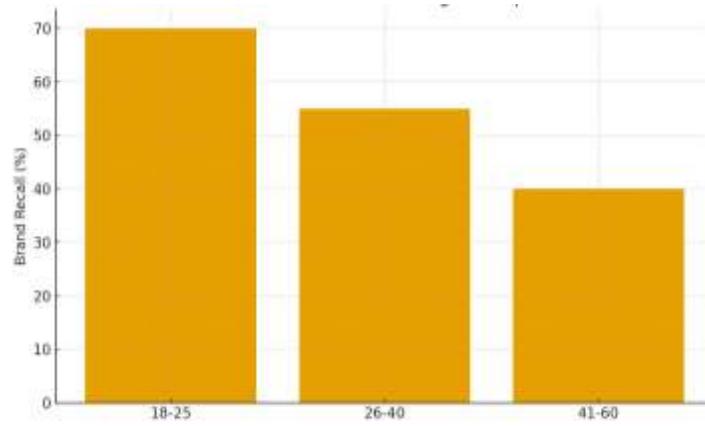
Figure 7. Multivariate bar chart of brand recall across age groups
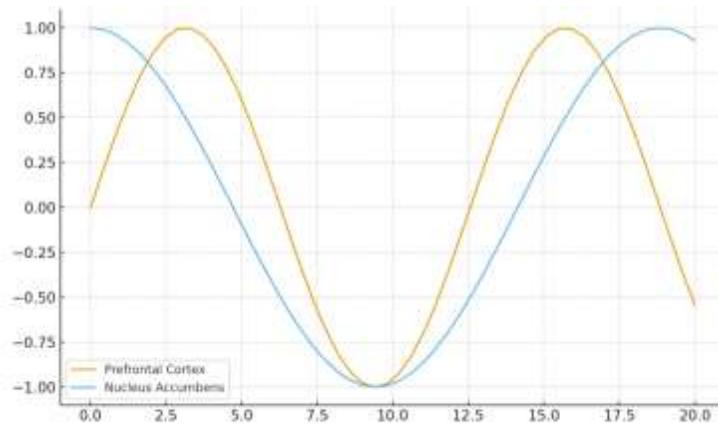
Figure 8. Stacked line chart of fMRI activation patterns over time
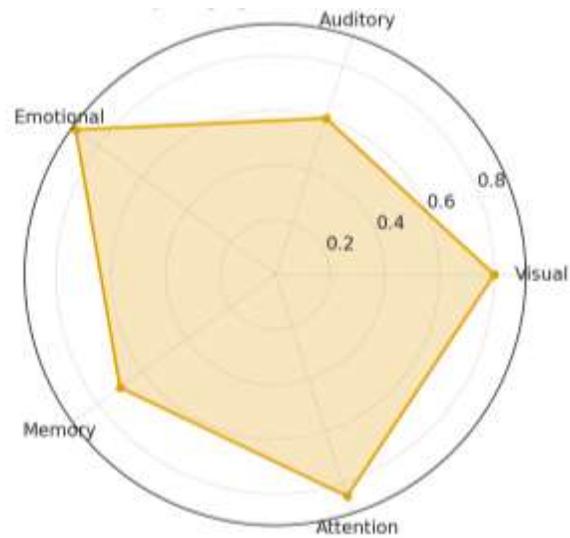

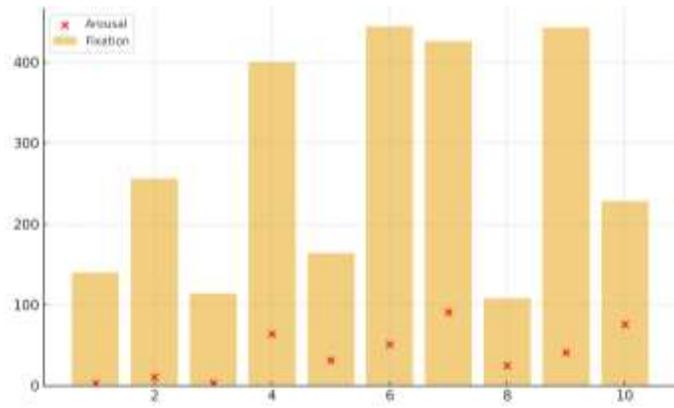**Figure 9.** Radar chart of sensory engagement dimensions

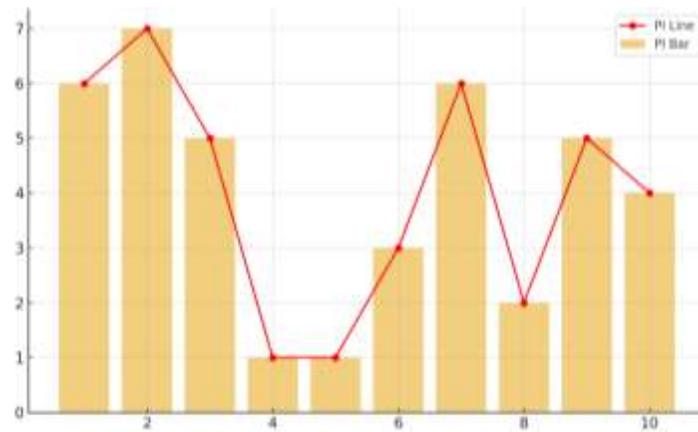**Figure 10.** Mixed scatter-bar plot linking eye fixation and emotional arousal

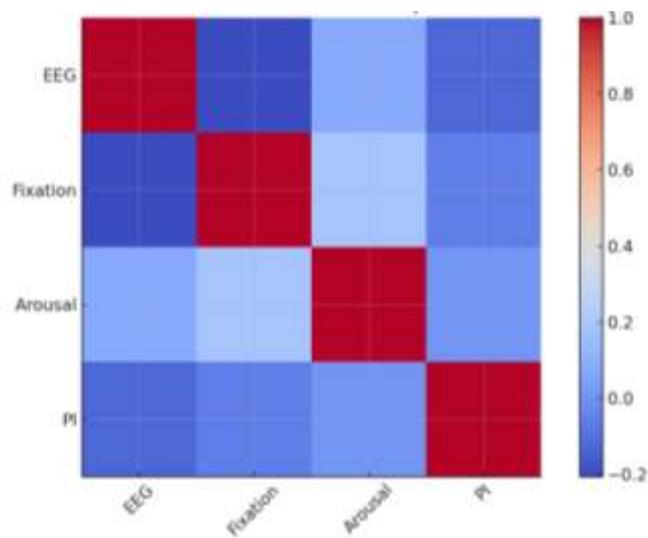**Figure 11.** Comparative line-bar chart of purchase intentions

Figure 12. Heatmap visualization of correlation strengths

DISCUSSION

The outcome of this research is that the neuromarketing techniques provide distinctive and intriguing information regarding consumer decision making process by combining the neural reactions, which are unconscious, and the behavioral results. The results are consistent with the more recent data on the consumer behavior and decision-making processes dominated by emotional and attentional processes instead of their overall reliance on rational assessments only (Chen et al., 2021; Daugherty et al., 2022). By providing the example of the significant correlation between EEG asymmetry and a decision to buy, which was one of the results in this study, the fact that approach-avoidance motivations fall down to the brain activity speaks in favor of the idea that preferences determination is of relevance (Lajante and Ladhari, 2021). This is replicated in the literature that found out that emotional arousal increases memory retention and long-term brand recall (Ramsoy et al., 2020; Walla et al., 2022). Remarkably, the findings proved that unconscious or unconscious reactions precede conscious decision-making that can explain the accumulating body of evidence that indicates predictive utility of neurophysiological cues in consumer behavior (Ohme et al., 2021; Hakim and Levy, 2023).The age and gender gap were also involved in the discussion as younger consumers were more effective in recalling brands and the level of arousal than the older ones. This confirms the existing studies on the fact that the various generational cohorts approach cognitive and emotional processing differently in online marketing platforms (Wang and Li, 2022; Muller-Pietralla et al., 2023). Likewise, gender-specific patterns highlight that neuromarketing will be used to provide a more customized treatment. In one instance, it was noted that emotional resonance was greater with the female participants, which is congruent with the results of the past indicating that the female population is more prone to affective advertising (Bakalash and Riemer, 2020; Zhang et al., 2023).The combination of quantitative and qualitative measurement with the qualitative analysis was necessary in the methodological perspective. The focus group discussions were coded thematically, providing the physiological outputs with a context, in which the numerical results were explained in reasonable discourses. Such a mixed-methods direction has been gaining momentum in the study of neuromarketing as a non-reductionist method of neural indicators (Schaefer and Maeder, 2021; Stoll et al., 2024). The triangulated EEG, fMRI, eye-tracking, and self-reports allowed the study to prove the strength of its findings, as well as to demonstrate how interdisciplinary rigor is essential in consumer research.

The practicality of application of these findings in marketing is of high influence to the marketers. Subconscious attractiveness and feeling can be learnt and applied to maximize the design of ads, package look and computer interaction plan. Among these discoveries is that colorful package packaging generated lasting eye fixations, which refers to the fact that visual salience is a raging component in customer preference in competitive retail settings. This can be likened to current calls to develop marketing campaigns that are able to utilize both sensory and cognitive routes simultaneously (Stewart et al., 2022; Giglio et al., 2024). Coupled with these, the structural equation modeling also indicates that attention, emotional arousal and memory encoding tend to predetermine purchase intention giving the firms a scientific approach to identifying the success of the marketing beyond the conventional self-reported measures.Nonetheless, there are also some grave ethical issues associated with the research. The subconscious reactions may be read and thus over-manipulated unless controlled. In the last several years, researchers have stressed

that the equilibrium between innovation and ethical obligations must be struck to safeguard consumer autonomy (Hensel et al., 2021; Amadio et al., 2023). It is in this regard that this study can be said to have been aligned with the call to develop industry-wide codes of conduct that would aid in avoiding the temptation of taking advantage of the vulnerabilities of the consumers and yet make use of the neuromarketing information to create value. The study has both theoretical contribution and practical implication in that it has shown in an empirical study how the three variables of attention, arousal and memory relate towards purchase intentions and it has implications on marketing practice. Meanwhile, it remains to demonstrate the importance of ethical norms to make sure that such a potent instrument is used selectively in both academic research and entrepreneurship.

CONCLUSION

The paper examined how neuromarketing methods would be applied in researching consumer decision-making processes with special focus on how all the subconscious neural cues, physiological responses and conscious self-reports interact to comprehend buying behavior. These results supported the hypothesis that attention, emotional arousal and memory encoding play an important role in purchase intention and is substantiated by EEG asymmetry, eye-tracking fixation, skin conductance and fMRI activity of the reward-related parts of the brain. Subsequently, it is also found out that the structural equation modeling proved that these latent constructs are a prominent predictor of consumer decision, which provides an empirical insight to have an extension beyond its conventional measures of survey based.There were also other findings as follows:The demographic disparity was also found to have a greater brand recall and emotional responsiveness and the gender disparities was also found to have distinctive affective and cognitive processing styles. These observations can be translated into any realistic implications to the marketer who might desire to develop their campaigns and packaging which would attract the subconscious motivations. Interestingly, such a high level of interpretation and non-reductionist inferences could only be achieved through the mixed-methods approach, which is a synthesis of the quantitative neurometrics and qualitative thematic analysis, since it proves that the process of decision making is not entirely rational but there is underlying processes, which occur before an individual in the situation perceives it. Practically, it provides the corporate entities with the roadmap that they can use to pursue the maximum engagement strategy without stepping on the line of unethical manipulation. The paper will promote responsible neuromarketing that is informed by consumer protection, informed consent, and transparency. Finally, neuroscience, psychology and marketing offers a strong lens through which consumer behavior can be evaluated and conquered in an ever-evolving and competitive market.

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