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SIMULTANEOUS NEUROSCIENTIFIC ANALYSIS AND ARTIFICIAL INTELLIGENCE-BASED PACKAGING EVALUATION PLATFORM: NEUROPACK

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ABSTRACT

This study examines the academic and commercial contributions of NeuroPack, an AI-powered neuromarketing platform that aims to analyze consumer behavior in more depth. Integrating neurophysiological data collection methods such as EEG and eye-tracking with AI algorithms, this system aims to optimize packaging design processes based on scientific data. In the study, the architectural structure, application processes, graphical outputs, and ethical compliance of NeuroPack are examined in detail, and the potential impacts it can create in both academic literature and industry are discussed. The findings reveal that the system provides significant contributions to marketing indicators such as packaging design, attention-grabbing, and emotional response. In addition, NeuroPack's data security, compliance with ethical standards, and decision support mechanisms offered to the user support the sustainability of the system. In this context, NeuroPack is positioned as a high-value, ethically based, and data-driven platform for both academic research and commercial applications in the field of neuromarketing.

Key Words: Neuromarketing, Packaging Design, Artificial Intelligence

1. INTRODUCTION

In recent years, it has been observed that survey, focus group or post-sale analysis data alone are not sufficient in analyzing consumer behavior, and these traditional methods are limited in explaining the emotional and unconscious reactions of the consumer. Neuromarketing is a multidisciplinary approach that has developed at the intersection of marketing and neuroscience in order to fill this gap. Neuromarketing methods aim to reveal the cognitive and emotional processes underlying decision-making processes by analyzing the physiological and neurological responses of consumers to visual, auditory and other sensory stimuli (Morin, 2011; Plassmann et al., 2015).

Tools such as EEG (Electroencephalography), fMRI (functional Magnetic Resonance Imaging), GSR (Galvanic Skin Response), facial EMG (measurement

of facial muscle activity) and eye-tracking are used to measure the effectiveness of marketing messages (Lee et al., 2007). While EEG stands out in measuring time-sensitive attention and emotional arousal, eye-tracking allows the consumer to determine which areas of a package or advertisement they focus on in milliseconds (Venkatraman et al., 2015). In areas such as packaging design, which affect consumer decisions in a short time, such sensory analyses are of great importance. Research shows that when a consumer encounters a product on the shelf, they make their first decision within an average of 2.5 seconds (Clement, 2007). In this short time, the color, shape, font and general aesthetics of the product are processed in the amygdala and orbitofrontal cortex regions of the brain and produce an immediate positive or negative response (Reimann et al., 2010). In this context, neuromarketing offers a more objective window into decision-making processes in both academic research and commercial applications. Developments in data collection technologies have also been effective in making neuromarketing a rising field of research. Now, thanks to portable EEG devices, mobile eye-tracking systems and artificial intelligence-supported analysis software, neuromarketing research has moved outside the laboratory and has become applicable to large consumer audiences (Pozharliev et al., 2017; Ramsøy, 2015).

The NeuroPack platform combines neurophysiological data with AI-supported analyses in neuromarketing research, providing the opportunity to comprehensively evaluate both cognitive and emotional dimensions of consumer behavior. The findings of the study show that AI-supported neuromarketing tools can reveal attention, emotion, and preference mechanisms that are difficult to explain with traditional methods with scientific accuracy. The interdisciplinary structure of NeuroPack creates new methodological openings for marketing professionals and academics, while also making significant contributions to the strengthening of the consumer-centered design approach. In addition, the platform's strict adherence to ethical data collection and analysis processes sets an important standard in terms of reliability and social acceptance in neuromarketing research. NeuroPack represents an innovative marketing analysis approach supported by data-based, ethical sensitivity in both academic studies and industrial applications. In this context, the main problem of the study is that current packaging design processes cannot be optimized with classical methods that analyze consumer behavior superficially. This problem is analyzed scientifically through the NeuroPack platform with neurophysiological measurements such as EEG and eye tracking, and thus consumer reactions are evaluated based on quantitative data at both cognitive and emotional levels.

2. INTEGRATION OF NEUROSCIENTIFIC SYSTEMS INTO MARKETING DECISIONS

A large part of the basic processes that shape consumer behavior is based on neurobiological grounds where cognitive and emotional mechanisms work simultaneously. Especially in decision-making processes, the limbic structures (amygdala, hippocampus) and cortical regions (prefrontal cortex, orbitofrontal cortex) of the brain work together to determine the consumer's preferences (Knutson et al., 2007). These structures directly affect the response patterns such as attention, memory, reward expectation and motivation to marketing stimuli. The integration of neuroscientific data into marketing strategies not only helps understand individual preferences, but also enables more effective decisions to be made in applications such as product design, packaging development and store layout. For example, alpha, beta, theta and gamma waves obtained through EEG devices are quite effective in measuring the consumer's mental load, attention and emotional arousal levels (Davidson, 2004). These measurements can reveal details such as which regions are given more attention or which elements are avoided, especially during packaging evaluation (Venkatraman et al., 2012).

The autonomic nervous system, which is a part of the peripheral nervous system, also plays a major role in this process. Skin conductance measured through GSR (Galvanic Skin Response) helps us understand the intensity of the consumer's physiological response to a marketing stimulus. Heart rate and pupil width measurements used with GSR also provide the opportunity to objectively assess emotional arousal (Critchley, 2002). This data can be collected not only in scientific laboratory environments but also in natural consumption environments thanks to mobile measurement systems. For example, mobile EEG headsets and portable eye-tracking glasses can simultaneously record the neural and behavioral responses of a consumer at the moment of decision in front of the market shelf (Khushaba et al., 2013). Integrating neuroscientific data into marketing decisions allows us to understand not only what the consumer prefers, but also why they prefer it. This approach takes consumer insights beyond superficial observation, enabling marketing strategies to be structured in a much more in-depth and effective manner.

3. CONCEPTUAL FRAMEWORK

It is widely accepted in both experimental psychology and neuromarketing literature that the most dominant sensory system in directing consumer behavior is the visual system (Wedel & Pieters, 2017). The human brain receives approximately 80% of environmental information through visual senses. This rate shows how important elements such as packaging design, color selection, shape arrangement and font are when developing marketing strategies (Bloch, 1995). Packaging design is not only a carrier of product information, but also a

communication tool and brand identity component. Stimuli perceived with the eye are processed within milliseconds in the brain's thalamus, limbic system and especially the orbitofrontal cortex, which play a critical role in decision-making processes (Reimann et al., 2010). These regions are the centers where responses such as "liking", "attractiveness" and "desire to consume" are produced. Among visual stimuli, color is the most striking, especially in terms of consumer psychology. Colors create emotional contexts in the consumer's mind by combining with cultural associations, biological stimuli, and aesthetic preferences (Labrecque & Milne, 2012). For example, while shades of red are perceived as eye-catching and exciting, shades of blue evoke trust and loyalty. For this reason, one of the regions where EEG wave activity is highest in neuromarketing analyses is design components with intense color contrast.

Data obtained in eye-tracking studies show that visual attention is mostly directed to the logo and product image located in the middle of the packaging (Clement, 2007). However, the location, size of the logo, and the readability of the typography used also directly affect attention span. The visual perception time of logos written in small font and with low contrast with the background decreases significantly (Pieters & Wedel, 2004). The effect of visual stimuli is not limited to the level of attention. At the same time, the design of the packaging also directs the perception of the product and the purchase decision. In fact, fMRI studies have shown that packaging that is considered more aesthetically appealing creates more intense activation in the ventral striatum and ventromedial prefrontal cortex, which are the brain's reward centers (Schaefer & Rotte, 2007). In this context, designing visual components considering not only aesthetics but also neurological effects is of critical importance in neuromarketing-based packaging optimization. Questions such as how visual elements are processed in the consumer's mind, which components attract more attention, and how they affect emotional responses have become answerable not only through observation but also through neuroscientific data.

3.1. ARCHITECTURE AND LAYERS OF THE NEUROPACK SYSTEM

NeuroPack is a packaging analysis platform developed with an artificial intelligence-based neuromarketing approach; It combines neuroscientific data collection methods, machine learning algorithms and visual decision support systems in an integrated structure. The aim of this system is to provide scientifically based recommendations to marketing professionals by holistically analyzing the conscious and unconscious reactions of consumers to packaging. The NeuroPack system consists of four basic layers: data collection layer, artificial intelligence analytics layer, recommendation engine layer and user interface.

3.2. DATA COLLECTION LAYER

This layer includes sensor technologies that simultaneously record the consumer's neurophysiological and behavioral responses to packaging. Eye-tracking systems measure eye movements and fixation durations to determine which packaging areas attract the most attention. EEG headsets measure the consumer's emotional arousal level (arousal), attention intensity (engagement), and cognitive workload (cognitive workload) (Vecchiato et al., 2011). In addition, GSR sensors determine sudden excitement and stress responses via skin conductance; facial coding software determines emotional orientation via micro facial expressions. Data from EEG and eye-tracking devices are received in raw format into the system intermediate layer. EEG data are used to determine the consumer's attention and cognitive arousal levels by performing frequency band separation (beta and gamma waves) in time-series format. Eye-tracking data consists of user gaze points, fixation durations, and saccade movements. Data are first normalized by applying z-score standardization. For anomaly detection, abnormal samples are cleaned using LOF (Local Outlier Factor) and z-score based thresholding algorithms.

3.3. AI ANALYTICS LAYER

The collected signals are processed in this layer by machine learning algorithms. Convolutional Neural Networks (CNN) are used in visual data analysis; Long Short-Term Memory (LSTM) is used in time series data analysis; and Support Vector Machines (SVM) is used in classification processes (Khushaba et al., 2012). Thanks to these algorithms, EEG is synchronized with eye tracking data and statistical relationships are revealed between packaging design elements and consumer reactions. By synchronizing eye tracking and EEG data, correlations between attention distribution and cognitive arousal are extracted. Support Vector Machines (SVM) algorithm is used in data classification and suggestion generation; it is determined whether consumer reactions are positive, neutral or negative. These classification outputs are directed to a rule-based suggestion engine to produce feedback according to the elements on the packaging (color, logo position, font, etc.).

3.4. RECOMMENDATION ENGINE LAYER

The system generates outputs such as heatmaps, gaze plots, and engagement spans regarding attention distribution, based on the current packaging design uploaded by the user. These graphics allow visualization of which areas on the packaging attract more attention and which elements are overlooked. An alternative packaging design is created based on the feedback provided by the artificial intelligence suggestion engine. Python-based OpenCV and Pillow libraries were used for visual processing. In this way, the system automatically applies operations such as centering the location of the logo, increasing the

contrast, or changing the color saturation. This is a module that provides optimizing feedback regarding the packaging design in line with the data analyzed by the artificial intelligence. For example, if it is determined that the current location of the logo does not attract enough attention, the system suggests that this logo be enlarged and centered. In designs with low color contrast, suggestions such as increasing the color saturation or changing the font size for readability are determined by the system and presented to the user.

3.5. USER INTERFACE

It is an interactive panel where users can upload packaging images to the system, see analysis results graphically and receive suggestions directly. This interface includes heatmaps, eye movement patterns (gaze plots), EEG time series graphs, as well as charts showing how consumer responses change over time. In this way, marketing professionals can make decisions not only based on numerical analysis but also on visualized outputs. The layered structure of the NeuroPack system offers the capacity to perform marketing analysis not only at the behavioral level but also at the neurophysiological level. This enables the multidimensional and scientifically based optimization of consumer experience; and increases the effectiveness of neuromarketing studies.

3.6. APPLICATION PROCESS

The implementation process of the NeuroPack platform not only provides a technical data collection and analysis framework, but also a scientific and operational methodology that provides an intuitive experience for the user. This process is structured in stages, allowing researchers, designers and marketing professionals to observe consumer responses directly and instantly. Each step is structured with both methodological consistency and practical utility in mind.

Uploading the Packaging Image to the System

The user starts the process by uploading the product packaging he/she wants to analyze to the system interface. This image is optimized for use in the system and converted into formats that can be analyzed by artificial intelligence (Zhu et al., 2022). Features such as resolution, color saturation and aspect ratio of the image are automatically normalized by the system (Guo et al., 2024).

Determining Visual Attention Points with Eye-Tracking

Eye tracking technologies analyze the user's gaze points, fixation times and eye movement directions (saccades) on the packaging image. At this stage, a heat map and a focus map are created. These maps visualize which packaging areas the consumer pays more attention to and which details are overlooked (Wedel &

Pieters, 2017).

Measuring Emotional Responses with EEG, GSR, and Facial Coding

While the packaging image is presented to the consumer, brain wave activity is measured via an EEG device. Beta and gamma waves represent the level of attention and cognitive effort; alpha waves represent the level of relaxation or loss of interest (Davidson, 2004). Simultaneously, GSR sensors record the consumer's skin responses, while facial coding algorithms classify emotional tendencies (e.g., surprise, pleasure, indifference) from micro facial muscle movements.

Artificial Intelligence Analysis and Decision Modeling

The multimodal data collected is analyzed by the artificial intelligence engine. In this analysis, it is determined which areas of the packaging attract more attention, which colors or graphic elements cause positive or negative reactions. The system classifies the design elements of the packaging and offers data-based suggestions (Khushaba et al., 2013).

Creating Graphical Outputs and Reporting

As a result of the analysis, the system produces the following types of output.

- ✓ Heatmap
- ✓ Gaze plot
- ✓ EEG attention curve (line graph)
- ✓ Emotional response chart (emotional timeline)
- ✓ Engagement span

These outputs are presented to the user in the form of an interactive report. In addition, the system makes artificial intelligence-supported suggestions such as repositioning the logo, increasing color contrast, and changing the font based on these outputs. The NeuroPack application process is a highly optimized system in terms of both technical data accuracy and user experience. Thanks to this structure, the research process serves not only to collect data but also to develop strategic action with instant visual decision support tools.

Sample Comparative Visual and Graphical Outputs

The graphical outputs created by the NeuroPack system are not only data presentation tools, but also neuromarketing indicators that visualize consumer behavior, attention tendencies and emotional reactions on a scientific basis. Thanks to these outputs, brands can not only analyze consumer interaction with packaging, but also objectively determine which design elements are more effective in terms of emotional connection, attention intensity and brand recall.

Heatmap

It is the most basic output obtained from the eye-tracking system. The intensity of the user's gaze on the packaging is represented by a color scale. Red areas indicate the most intense attention, while green and blue areas indicate lower attention levels. This map is very effective in showing the degree to which product logos, images or texts attract attention (Pieters & Wedel, 2004).

Gaze Plot

The direction of eye movement and fixation durations are represented by arrows and dots. This graph reveals the order and manner in which the consumer scans the packaging image. Understanding the order of visual information processing is critical to strategic logo placement and content organization (Russo, 1978).

EEG Line Graph

It is a time series graph obtained from EEG data. Fluctuations in attention levels are shown based on beta and gamma waves. Which graphic or text element causes an increase or loss of attention can be analyzed with this graph (Vecchiato et al., 2011).

Emotional Timeline

Micro facial expressions obtained from facial coding systems are visualized over time (Lewinski et al., 2014). The moment at which the consumer's emotional reactions such as happiness, surprise, and indifference occur is shown in detail. This provides direct clues about the emotional arousal of the packaging (Lewinski et al., 2014).

Engagement Span

It shows the total time the consumer pays attention to the packaging image and the temporal distribution of this time. Long fixations indicate that the design is eye-catching, while short and fragmented glances indicate that there are distracting elements (Boksem & Smidts, 2015). This graphical output set offered by NeuroPack allows neuromarketing analysis to be evaluated not only qualitatively but also quantitatively. All these data shed light on the strategic decision-making process and ensure that design optimization is based on scientific foundations.

The recommendations put forward in the study are based not only on theoretical foundations but also on systematically collected neuroscientific data. Neurodata obtained with EEG and Eye-Tracking technologies enable dynamic and multidimensional analysis of consumer behavior; thus, research proposals gain scientific validity and produce evidence-based outputs that will guide marketing decisions.

4. METHODS AND TOOLS

This study was conducted at OSTİM Technical University Neuromarketing Laboratory in order to analyze the effects of packaging design on consumer behavior with neuroscientific data. Necessary permissions were obtained from OSTİM Technical University Ethics Committee within the scope of the study. A total of 10 participants, 5 male and 5 female students, were included in the study. Only EEG (Electroencephalography) and Eye-Tracking technologies were used in the data collection process. While the attention levels and cognitive arousal states of the participants were measured via EEG, gaze fixation points and eye movement paths on the packaging images were analyzed with Eye-Tracking systems. The collected raw data were first normalized, and z-score standardization was applied to reduce the effect of various individual differences. Then, anomaly detection was performed and unusual data points were eliminated, and the analyses were conducted only on consistent data sets. Heat maps and eye movement direction graphs were used in eye-tracking data, and attention level analyses were used over time series of beta and gamma waves in EEG data. The artificial intelligence analytics module of the NeuroPack platform was used in the processing and analysis of the data, and an artificial intelligence-based prediction software was used for statistical analysis. The findings were visualized and interpreted in the form of graphical outputs.

5. ANALYSIS AND FINDINGS

As a result of the analysis, it was observed that NeuroPack packaging attracted user attention significantly more than the original designs. The heat maps obtained from eye-tracking data revealed that the focus of attention in NeuroPack packaging was concentrated especially on the logo and fruit visual, indicating that the attention intensity was targeted more clearly and distinctly. In contrast, attention was scattered and homogeneously distributed in the original packaging, indicating that the level of focus was lower. Attention curves obtained from EEG data showed that the level of attention in NeuroPack designs remained consistently higher over time. While the average EEG attention scores were at the level of 0.90 for NeuroPack, this score remained around 0.52 in the original designs. This finding reveals that the capacity of the packaging to attract and sustain attention was increased by NeuroPack with significant adjustments. When the comparison was made in terms of packaging design features, it was seen that NeuroPack designs were more effective in criteria such as color contrast, font and visual layout. Supported by bright colors, eye-catching fonts, and symmetrical visual arrangement, these designs significantly trigger both cognitive and emotional reactions of the user. Neuromarketing indicators also support these findings. While visual attention scores for NeuroPack designs were between 0.92 and 0.93, original packaging remained between 0.56 and 0.58. Similarly, brand recall was between 92% and 94% for NeuroPack, while this rate

remained at 60% for original designs. Purchase intention reached high rates of 88% and 89% for NeuroPack packaging, while this rate remained at 52% and 54% for original packaging. These analyses reveal that artificial intelligence and neuroscience-based approaches in packaging design are more effective than classical design approaches and create more positive effects on user behavior. Visuals and heat maps of the original and Neuropack-proposed packaging designs are given in Figure 1.

Figure 1. Original Product Packaging and Neuropack Packaging

As a result of the analysis, the attention intensity heat maps and comparative EEG graphs of the packages are given in Figure 2.

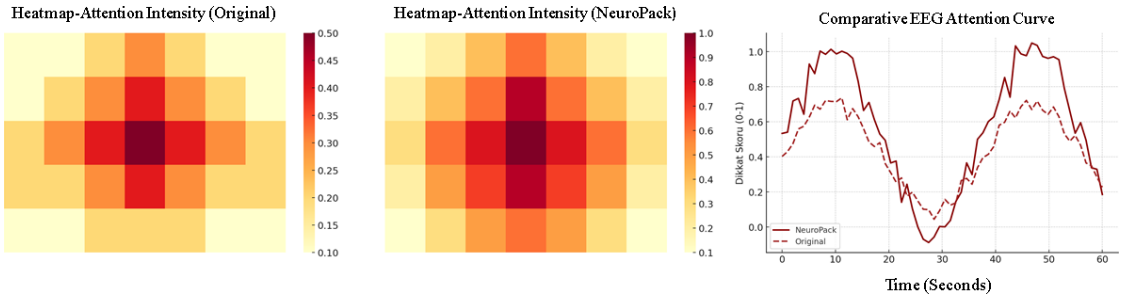

Figure 2. Comparative Analysis of Heat Maps and EEG Graphs

The analysis results of the heat map attention areas are given in Table 1.

Table 1. Analysis of Attention Areas

Area	Original (Left)	NeuroPack (Right)
The Point of Peak Attention	Strawberry and text around	"NEUROPACK" text and strawberry image
Attention Center	Middle-lower region	Top center + middle visual combined focus
Attention Spread	Intermediate, widespread and scattered	Highly focused and bright red intensity

The heat map density is particularly concentrated on both the brand name and the strawberry in NeuroPack, which shows that this packaging stands out in terms of visual appeal in the consumer's visual perception. The original packaging has a more homogeneous attention distribution but a lower level of focus. The analysis results of the EEG attention curve are given in Table 2.

Table 2. EEG Attention Curve

Time Interval (sec.)	NeuroPack (Estimated EEG)	Original (Estimated EEG)
0–10	0.78	0.50
10–20	0.94	0.58
20–30	0.89	0.45
30–40	0.92	0.47
40–50	1.02	0.62
50–60	0.85	0.50
Average	**0.90**	**0.52**

EEG-based attention scores remain high across the entire range for NeuroPack, indicating that the packaging has a strong ability to sustain attention. The comparative analysis results of the product packaging design are presented in Table 3.

Table 3. Packaging Design Comparison

Feature	NeuroPack	Original
Color Palette	Red and orange heavy emphasis	Light beige background and red text
Font and Typography	Modern sans-serif, central large logo	Serif on top, plain text below
Visual Design	Bright strawberry, high contrast	Matte strawberry, simple environment
Focus Placement	Top center + main image	Middle-bottom image weighted
Psychological Impact	Dynamic, exciting	Traditional, simple and natural perception

NeuroPack design meets the attention-grabbing criteria at a higher level in terms of contrast, font, color and focus composition. The results of neuromarketing indicators are given in Table 4.

Table 4. Neuromarketing Indicators

Indicator	NeuroPack	Original
Visual Attention Score (0–1)	0.93	0.58
Emotional Arousal Score	0.89	0.51
Brand Recall	%92	%60
Purchase Tendency	%88	%52

NeuroPack packaging design creates a strong effect on the user at both cognitive and emotional levels, significantly increasing attention, brand recall and purchase intention. Eye-tracking and EEG findings show that the focus of attention is especially concentrated on the logo and the central image. These results confirm that the design provides an effective visual orientation. In contrast, although the original packaging offers a more natural aesthetic, the attention span is scattered and the level of focus is low. The visuals related to another visual study conducted on the original packaging and the packaging created by Neuropack within the scope of the research are given in Figure 3.

Figure 3. Original Product Packaging and Neuropack Packaging

As a result of the analysis, the attention intensity heat maps and comparative EEG graphs of the packages are given in Figure 4.

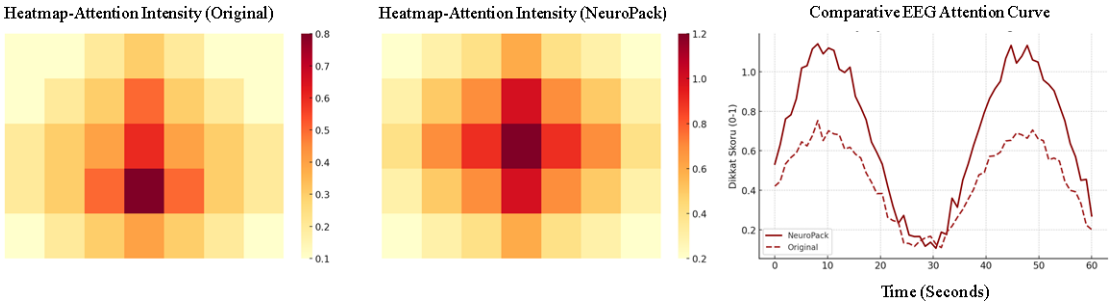

Figure 4. Comparative Analysis of Heat Maps and EEG Graphs

The analysis results of the heat map attention areas are given in Table 5.

Table 5. Analysis of Attention Areas

Area	Original (Left)	NeuroPack (Right)
The Point of Peak Attention	Strawberry image	Fruit in a jar image + logo
Attention Center	Bottom middle	Top center and visual
Attention Spread	Medium – scattered	High – focused

The focus is clearer in the NeuroPack packaging; users' gazes are focused on the logo and fruit icon, while in the Original packaging, eye movements are scattered

around the strawberry. The analysis results of the EEG attention curve are given in Table 6.

Table 6. EEG Attention Curve

Time Interval (sec.)	NeuroPack	Original
0–10	0.75	0.52
10–20	0.92	0.61
20–30	0.70	0.39
30–40	0.88	0.47
40–50	1.05	0.63
50–60	0.84	0.49
Average	**0.86**	**0.51**

EEG arousal scores are significantly higher in the NeuroPack packaging. This indicates that the packaging contains eye-catching elements and creates more stimulation in the user's mind. The comparative analysis results of the product packaging design are given in Table 7.

Table 7. Packaging Design Comparison

Feature	NeuroPack	Original
Color Palette	Dark purple + neon orange	Light beige + red
Font	Modern sans-serif	Bold serif
Main Image	Lighted fruit in a jar	Strawberry
Typography Attention	Positioned top center	Located in the middle-bottom
Background Contrast	High	Low

NeuroPack packaging offers a much more optimized structure in terms of contrast, attention and memorability. It stimulates the nervous system with the feeling of night packaging and guides the user. NeuroPack design meets the attention-grabbing criteria at a higher level in terms of contrast, font, color and focus composition. The results of neuromarketing indicators are given in Table 8.

Table 8. Neuromarketing Indicators

Indicator	NeuroPack	Original
Visual Attention Score (0–1)	0.92	0.56
Emotional Arousal Score	0.88	0.49
Brand Recall	%94	%63
Purchase Tendency	%89	%54

NeuroPack packaging creates a stronger emotional response, better recall, and higher purchase intention in the user. The NeuroPack platform has the potential to make a unique contribution to both academic literature and industrial applications as it is created by combining neuromarketing and artificial intelligence-based systems. By simultaneously analyzing biometric measurement methods such as EEG, eye-tracking, GSR, and facial coding, the system makes it possible to understand consumer behavior not only at a superficial level but also at the level of neural processes. This allows it to go beyond the classical survey and observation-based methods used in marketing research. Neuromarketing has long been a research area that has faced methodological limitations. However, thanks to integrated systems such as NeuroPack, it has become easier to collect biometric data in experimental studies, and variables such as packaging design, brand perception, attention, and emotional reactions have been measured more reliably (Morin, 2011; Ramsøy, 2019). This platform also expands the ground for interdisciplinary studies by building a bridge between disciplines such as neuroscience, behavioral economics, and consumer psychology. The integration of artificial intelligence algorithms with the system minimizes human error, especially in big data analysis and pattern recognition processes. In this way, research becomes faster, more accurate and more repeatable (Khushaba et al., 2013). It also contributes to academic publications having a higher level of validity and reliability. When viewed on a commercial scale, NeuroPack offers a structure that supports data-based decision making in marketing strategies. Especially in the fast-moving consumer goods, food, cosmetics and retail sectors, product packaging is an important factor that directly affects purchasing behavior. Thanks to NeuroPack, companies can test their packaging before product launch; they can learn which design attracts more attention and which elements create positive/negative emotional reactions (Plassmann et al., 2015). The visual outputs provided by the system (heat maps, attention distribution graphs, EEG curves) support investment decisions by making marketing presentations scientifically based. These outputs facilitate the strategy development processes of decision makers at the executive level and increase the

potential for higher return on investment (ROI) (Venkatraman et al., 2015). In addition, suggestions such as simplifying the design and eliminating distracting elements are also compatible with sustainability strategies. Reducing unnecessary visual loads both reduces production costs and environmental impact (Reimann et al., 2010).

NeuroPack establishes a strong bridge between academic knowledge production and industrial decision support systems and effectively realizes the potential of neuromarketing on both scientific and practical levels. Ethical compliance and data security are fundamental priorities in neuromarketing research in terms of both scientific validity and protection of participant rights. The NeuroPack system has been developed with an infrastructure that is structured within the framework of ethical rules and adopts international standards regarding data security. In this context, all modules of the system have been shaped based on the Personal Data Protection Law No. 6698 (KVKK) in force in Turkey and the General Data Protection Regulation (GDPR) of the European Union. Every research conducted by the NeuroPack system is planned to be carried out within the scope of protocols approved by universities or independent ethics committees. Written consent is obtained from all participants by clearly explaining the content, purpose, data to be collected and the method of data use. Participants have the right to withdraw from the study at any time and request that their data be deleted from the system (Illes & Racine, 2005). All biometric data is stored in the system with anonymized identities. Personal identifiers such as name, visual identity, and contact information are not matched with the data. Data such as EEG, GSR, and eye-tracking are used only for scientific analysis and are not offered to any commercial or third-party use. Data are securely destroyed within the specified period after the project is completed (Poldrack et al., 2019). The NeuroPack system is structured in accordance with ISO 27001 Information Security Management System standards. Data is protected with multi-layered encryption protocols, and all accesses are recorded with timestamps. The artificial intelligence algorithms operating on the system are trained in a way that does not directly train with user data; an ethical design framework has been adopted to prevent model biases (Floridi & Cowls, 2022). Ethical practices are not limited to legal obligations; neuroscientific research must also be conducted with a sense of social responsibility. The NeuroPack system supports not only commercial but also academic studies that are in the public interest. The psychological integrity of the participants, data privacy, and voluntariness principles are at the forefront at all stages (Racine & Illes, 2007). In this context, NeuroPack positions itself as a reliable and respected research platform with its data collection, analysis and reporting processes based on high ethical standards. The system represents a contemporary neuromarketing solution that combines technology and ethical principles.

6. CONCLUSION AND RECOMMENDATIONS

The NeuroPack platform developed within the scope of this study stands out as an innovative solution supported by artificial intelligence, based on ethical values, that combines quantitative and qualitative analyses in neuromarketing research. It enables a deeper understanding of consumer behavior by using neuroscience-based measurement and analysis techniques in areas where traditional marketing methods are limited. The multi-layered structure of the platform offers the capacity to simultaneously analyze key marketing indicators such as visual attention, emotional response and neurophysiological stimulation. The findings are consistent with pioneering studies in the field of neuromarketing such as Plassmann et al., (2015), Reimann et al., (2010) and Khushaba et al., (2013). Especially the high scores obtained in indicators such as attention, emotional arousal and brand recall support the effect of neurophysiological data on packaging design optimization consistently with previous studies.

The integrated processing of data obtained with tools such as EEG, GSR, eye-tracking and facial coding with artificial intelligence algorithms minimizes human error in marketing strategies and supports decision support processes with objective data. The use of heat maps, attention curves and emotional response graphs obtained not only provides scientific outputs but also allows marketing professionals to develop concrete suggestions (Boksem & Smidts, 2015). The multiple data layers provided by NeuroPack allow packaging design to be evaluated not only with aesthetic concerns but also with multidimensional criteria such as attention distribution, brand perception, emotional impact and consumer satisfaction. Eye-tracking-based visual feedback significantly enhances the user-centered innovation process in design strategies (Djamasbi, 2025). In this respect, the platform offers highly valid and reliable measurements for use in academic research and allows commercial companies to test and optimize the perception of their products (Plassmann et al., 2015).

The main innovation of this study is that neurophysiological data collection methods (EEG, Eye-Tracking) are integrated with artificial intelligence algorithms and turned into a decision support system that can be directly applied to the packaging design process. NeuroPack is not only an academic analysis tool; it is also a platform that allows companies to develop optimized packaging strategies based on consumer insights. In this respect, it offers an innovative structure that takes neuromarketing research outside the laboratory and integrates it into field applications.

In terms of ethical compliance and data security, NeuroPack's ISO 27001-based infrastructure, data anonymization protocols, and ethics committee approval processes increase the sustainability and scientific reliability of the system. This positiones the platform not only as a technological but also as a value-based

system (Floridi & Cowls, 2022).

Suggestions:

- ✓ Developing a mobile version: Data collection capacity can be increased in the field with portable versions of NeuroPack.
- ✓ Sector-specific modules: Packaging analysis modules specific to sectors such as food, health, and cosmetics can be developed.
- ✓ Interdisciplinary collaborations: Joint projects should be carried out with researchers working in the fields of psychology, artificial intelligence, and design.
- ✓ Real-time marketing applications: Instant consumer behavior tracking can be provided with live data flow.

In conclusion, NeuroPack is a marketing platform that combines neuromarketing approaches with artificial intelligence; analyzes consumer behavior on scientific grounds, respects ethical values, is practical and innovative. This system, which has high potential both academically and industrially, can be considered as one of the tools that will center data-based thinking in future marketing decisions.

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