Articles

# Artificial Intelligence Applied to Biometrics in Personalized Digital Marketing: A Systematic Review

## Inteligencia artificial aplicada a la biometría en marketing digital personalizado: revisión sistemática

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## ABSTRACT

The objective of this research was to analyze, through a systematic literature review, the integration of eye-tracking, voice analysis, and physiological biometrics technologies with artificial intelligence algorithms for the personalization of experiences in digital marketing. The PRISMA methodology guidelines were followed. Searches were conducted in Scopus, Web of Science, SciELO, and Google Scholar, using combinations of keywords and Boolean operators. Open-access articles published in the last five years were selected. Of the total identified (n = 8,068), after removing duplicates and screening via automation and title/abstract, 174 full-text articles were evaluated; ultimately, 13 studies met the eligibility criteria. The findings showed that the integration of eye-tracking, voice analysis, and biometrics with AI improves segmentation, optimizes creativity, and enables the real-time personalization of ads using physiological and behavioral signals. This enhances both the user experience and campaign efficiency. Furthermore, benefits were identified in the prediction of attention, brand recognition, and emotional engagement, along with the ethical and legal

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challenges related to the handling of biometric data. It is concluded that the integration of biometric technologies with AI yields favorable results for the hyper-personalization of the digital marketing experience; facilitates the prediction of attention patterns and brand recognition; and increases customers' perception of trust and the emotional effectiveness of campaigns. The study stands out by framing the impact of these technologies on emotional personalization, an aspect rarely addressed in previous reviews. Furthermore, it proposes a critical-ethical approach that opens new lines of research on trust and regulation in neuromarketing.
**Keywords:** eye tracking, voice analysis, biometrics, artificial intelligence, personalized digital marketing.

## RESUMEN

El objetivo de esta investigación fue analizar, mediante una revisión sistemática de la literatura, la integración de tecnologías de Eye-Tracking, análisis de voz y biometría fisiológica con algoritmos de inteligencia artificial para la personalización de experiencias en marketing digital. Se siguieron las directrices de la metodología PRISMA. Se realizaron búsquedas en Scopus, Web of Science, SciELO y Google Scholar, empleando combinaciones de palabras clave y operadores booleanos. Se seleccionaron artículos de acceso abierto publicados en los últimos cinco años. Del total identificado (n = 8068), tras la eliminación de duplicados y el cribado por automatización y título/resumen, se evaluaron 174 textos completos; finalmente, 13 estudios cumplieron criterios de elegibilidad. Los hallazgos evidenciaron que la integración de eye-tracking, análisis de voz y biometría con IA mejora la segmentación, optimiza la creatividad y permite personalizar anuncios en tiempo real mediante señales fisiológicas y conductuales. Esto incrementa tanto la experiencia del usuario como la eficiencia de las campañas. Asimismo, se identificaron beneficios en la predicción de atención, reconocimiento de marca y engagement emocional, junto con los retos éticos y legales relacionados con el manejo de datos biométricos. Se concluye que la integración de tecnologías

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biométricas con IA aporta resultados favorables para la hiperpersonalización de la experiencia en marketing digital; facilita la predicción de patrones de atención y el reconocimiento de marca; e incrementa la percepción de confianza del cliente y la efectividad emocional de las campañas. El estudio se distingue al enmarcar el impacto de dichas tecnologías en la personalización emocional, un aspecto poco abordado en revisiones previas. Además, propone un enfoque crítico-ético que abre nuevas líneas de investigación sobre confianza y regulación en neuromarketing.

**Palabras clave:** seguimiento ocular, análisis de voz, biometría, inteligencia artificial, marketing digital personalizado.

## INTRODUCTION

Both neuromarketing and communication research have explored the relationships between eye-tracking (ET) and artificial intelligence (AI) for marketing management. Thus, the integration of advanced technologies such as ET in conjunction with AI algorithms has brought about a transformation, particularly in digital marketing, by enabling the creation of dynamic and highly personalized experiences (Kondak, 2023).

The study by Šola et al. (2025) analyzed how elements such as background color and content structure can influence engagement, cognitive processing, and emotional responses among people who consume advertisements or online articles. To obtain these results, the authors used AI-based ET, in addition to other neuromarketing techniques. This proved to be a key factor in designing digital content aimed at influencing consumer engagement and information retention.

Meanwhile, Boerman and Müller (2022) revealed, following an eye-tracking study, that Instagram users pay more attention to brand tags in images and paid collaboration tags. Thus, the eye-tracking technique—using artificial intelligence to design the evaluation tools—determined that disclosures, brand presence, and the type of influencer influence the level of understanding regarding conceptual persuasion.

A study by Li et al. (2022) demonstrates that attention-based marketing allows for the direct measurement of visual attention to advertising stimuli using eye-tracking technology. According to top-down processing, stimuli that are more relevant or congruent to the audience are likely to attract more fixations. This processing involves top-down factors (i.e., engagement with the product, motivation, and brand familiarity) in the individual that influence attention capture. This was tested in a series of tourism recommendations to consumers using ads delivered by brand ambassadors.

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Meanwhile, the incorporation of voice analysis and biometrics—powered by artificial intelligence algorithms—is also being used in digital marketing to identify users' emotional states. In turn, this helps to understand the user's intent. This facilitates the design of more personalized messages and enhances the customer experience across channels such as contact centers and virtual assistants (De Kloet & Yang, 2022). Although this study dates from 2022, it brings to the table the discussion on the use of AI in various marketing and customer relationship strategies—including aspects such as recognition and authentication; natural language processing; intelligent personalization; and user experience.

It is important to note that in marketing, biometrics is used to deliver personalized experiences based on the recognition of consumers' physical reactions. To this end, physiological or behavioral characteristics unique to the consumer—such as facial features, voice, keystroke patterns, and fingerprints—are utilized (De Keyser et al., 2021). Voice analysis technology, on the other hand, consists of systems that transcribe conversations, which helps extract both qualitative information such as emotional states, accent, and gender. This allows for consumer segmentation, as well as the evaluation of customer perceptions and the diagnosis of campaign failures (Hildebrand et al., 2020).

On the topic of voice analysis itself, the study by Teskeredzic et al. (2025) stands out; they use AI to create marketing campaigns based on voice capabilities. To do so, they employ audio processing techniques. This generates interactive experiences that foster user engagement and facilitate the acquisition of prospective customers. The system used, called Vocalize, was presented at four live events and demonstrated significant audience engagement, opening up new possibilities for gamified audio campaigns in marketing and branding.

Thus, this review serves as a valuable resource for systematizing the results of existing studies on the relationship between these technologies integrated into marketing and their connection to artificial intelligence. Given the rise of AI in various areas of life—both academic and everyday—this study aims to consolidate criteria regarding its impact on market strategies for identifying, attracting, and retaining potential customers. Therefore, this article aims to analyze, through a systematic literature review, the integration of eye-tracking, voice analysis, and physiological biometrics technologies with artificial intelligence algorithms for the personalization of experiences in digital marketing.

## MATERIALS Y METHODS

A systematic literature review was conducted using the PRISMA methodology (Page et al., 2021), which facilitated the process of selecting, screening, and analyzing articles that met the criteria for quality and rigor in accordance with the topic under study. To this end, the primary sources of information were databases such as Scopus, Web of Science, Google Scholar, and SciELO, between August 6 and September 4, 2025. The search

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strategy was implemented using keywords, also referred to as descriptors depending on the database. Combinations were created using the Boolean operators AND and OR. Thus, the search strategy was constructed as follows:

**Table 1.** *Search strategy using keywords*

| Keywords/descriptors (Scopus, WoS, Google Scholar) | Keywords (Scielo, Google Scholar) |
|---|---|
| "eye tracking" OR "gaze tracking" OR "oculography" AND "marketing" | "eye tracking" OR "gaze tracking" OR "oculography" AND "marketing" |
| "voice analysis" OR "speech analytics" OR "speech recognition" AND "marketing" | "voice analysis" OR "voice analytics" OR "voice recognition" AND "marketing" |
| "biometrics" OR "behavioral biometrics" OR "physiological signals" AND "marketing" | "biometrics" OR "behavioral biometrics" OR "physiological signals" AND "marketing" |
| "eye tracking" AND "digital marketing" AND "artificial intelligence" | "eye tracking" AND "digital marketing" AND "artificial intelligence" |
| "voice analysis" AND "digital marketing" AND "artificial intelligence" | "voice analysis" AND "digital marketing" AND "artificial intelligence" |
| "biometrics" AND "digital marketing" AND "artificial intelligence" | "biometrics" AND "digital marketing" AND "artificial intelligence" |
| "Consumer Behavior" AND "Digital Marketing" OR "Customer Experience" AND "eye tracking" OR "voice analysis" OR "biometrics". | "consumer behavior" AND "digital marketing" OR "customer experience" AND "eye tracking" OR "voice analysis" OR "biometrics" |

Compiled by the authors based on the search strategy for indexed databases.

The following inclusion and exclusion criteria were considered for article selection:

### Inclusion Criteria

Articles in English and Spanish that comply with Open Science policy, published within the last 5 years in journals indexed in the aforementioned databases, and that address the topics of eye tracking, voice analysis, and biometrics as part of digital marketing strategies and with the use of artificial intelligence.

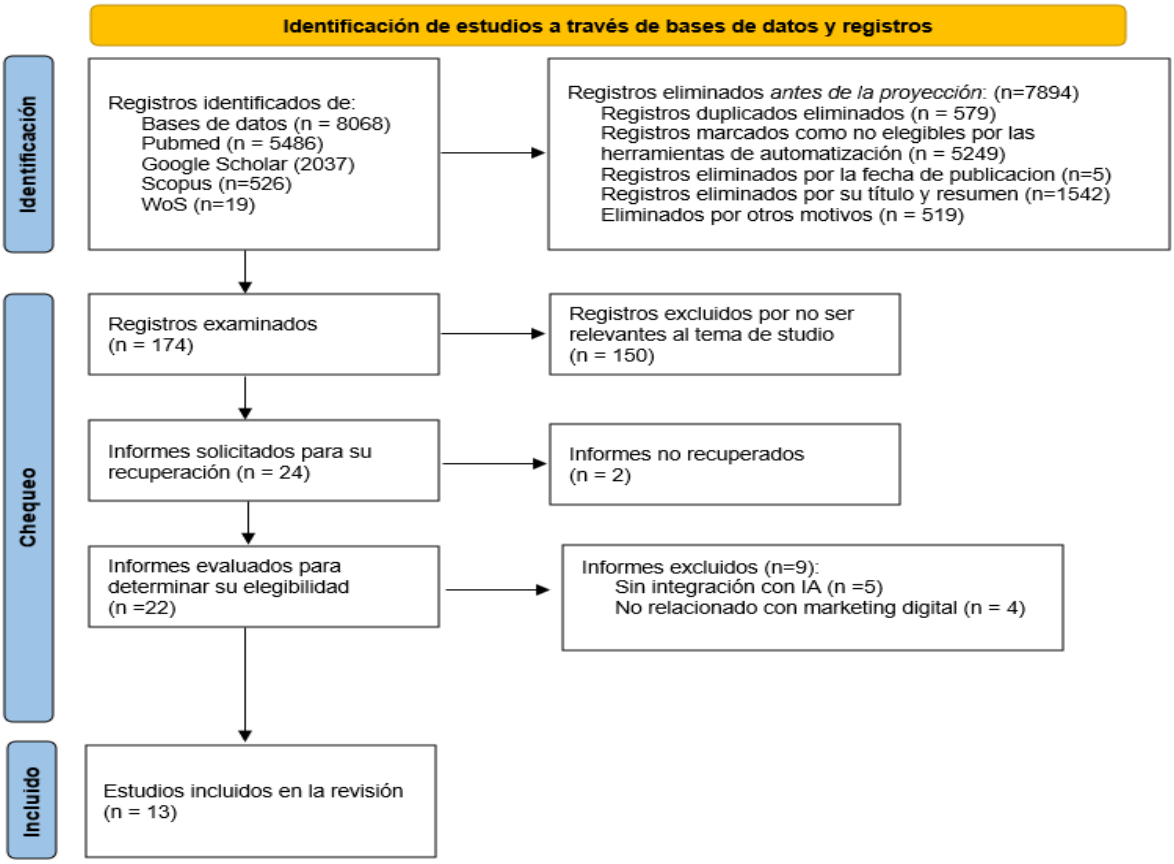
### Exclusion Criteria

Articles published more than five years ago, those that did not adhere to the Open Science policy, as well as letters to the editor, theses, and papers with unclear methodologies were excluded. Studies that did not focus on digital marketing and artificial intelligence were also excluded.

Based on these criteria, the selection and screening process was conducted for the articles retrieved from each database, in accordance with the PRISMA guidelines.As shown in the PRISMA diagram (Figure 1), 8,068 eligible articles were identified. Of these, 579 duplicates were removed prior to screening; 5,249 were flagged as ineligible by Rayyan's automation tools; 5 were excluded based on their publication date; 1,542 were excluded based on their title and abstract; and 519 for other reasons (language, accessibility, methodological quality). A total of 174 articles were reviewed; of these, 150 did not provide information relevant to the objective of this systematic review, and 2 articles were not retrieved (retracted), leaving 22 articles; of these, 5 were excluded

for failing to describe integration with AI and 4 for not being applicable to the field of digital marketing, leaving 13 articles, which were included in this systematic review.

***Figure 1*** . PRISMA Diagram




Created by the authors.

To ensure the rigor of the process, reference management and the removal of duplicates were performed in Rayyan. Two independent reviewers applied the inclusion and exclusion criteria to titles and abstracts; disagreements were resolved by consensus and, when necessary, with the intervention of a third reviewer. The level of inter-rater agreement, considered substantial, was calculated using Cohen's kappa coefficient, which supports the consistency of the procedure.

The methodological quality of the included articles was assessed qualitatively, based on criteria of clarity in the methodological description, rigor in the experimental design, transparency in the reporting of results, and relevance to the study's objective—defined as the integration of biometric technologies (eye tracking, voice analysis, and

physiological biometrics) with artificial intelligence algorithms applied to digital marketing for the personalization of experiences. This process ensured that the selected studies provided solid and relevant evidence for the analysis, even in the absence of the formal application of standardized bias risk assessment tools.

Based on the selected articles, a qualitative analysis was conducted that focused on systematizing the criteria found in the literature regarding the integration of eye-tracking, voice analysis, and biometric technologies with artificial intelligence algorithms for the personalization of experiences in digital marketing.

Data extraction was performed systematically from the articles included in the review. The following variables were collected for each study:

- General information: author, country of origin, year of publication, and type of methodological design.
- Context of application: sector or study setting (e-commerce, social media, digital magazines, among others).
- Sample characteristics: number of participants, sociodemographic profile, and selection criteria.
- Technological approach: use of eye-tracking techniques, voice analysis, or biometrics.
- Metrics used: indicators specific to each technology, such as duration and number of eye fixations, areas of interest (AOIs), accuracy of machine learning algorithms, and facial or voice recognition metrics.
- Artificial intelligence algorithms used: support vector machines (SVM), convolutional neural networks (CNN), deep learning models, and other classification and prediction systems.
- Key results: most relevant findings in terms of advertising effectiveness, audience segmentation, attention prediction, emotional engagement, and message personalization.
- Ethical and legal aspects: considerations regarding the processing of biometric data, informed consent, and privacy policies.

## RESULTS

Of the 13 included studies, 8 were experimental (3 using eye-tracking; 2 using EEG and machine learning; 2 online experiments; and 1 laboratory experiment involving lighting conditions), 2 were narrative reviews, and 3 were systematic reviews. The applications ranged from interfaces and e-magazines to e-commerce and social media, as well as voice assistants, using metrics such as attention (fixations/AOIs, clarity, cognitive load), preference/engagement, and authentication/security. Regarding Artificial Intelligence (AI), machine learning algorithms such as SVM and deep learning models (encoder–decoder, ConvNeXt) focused on prediction and personalization predominated: Overall,

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the evidence supports more precise segmentation and real-time personalization, which benefits the user experience (UX) and creative effectiveness.

Thirteen articles were selected for this systematic review, all of which were published between 2021 and 2025 (Almourad et al., 2025; De Kloet & Yang, 2022; Gökhan & Aydin, 2022; Ishtiaque et al., 2025; Kaponis et al., 2024; Kemora et al., 2024; Kondak, 2023; Mashrur et al., 2022; Mauri et al., 2021; Saleh & Zeebaree, 2025; Šola et al., 2024, 2025; Yüksel, 2023). Eight of these articles employed an experimental design, of which three used eye-tracking (laboratory, HCI) (Almourad et al., 2025; Šola et al., 2024, 2025), two used EEG and machine learning (Ishtiaque et al., 2025; Mashrur et al., 2022), two online between-subjects experiments (De Kloet & Yang, 2022; Mauri et al., 2021), and one controlled laboratory experiment conducted under natural light (Yüksel, 2023). In addition, two narrative reviews (Gökhan & Aydin, 2022; Kaponis et al., 2024) and three systematic reviews (Kemora et al., 2024; Kondak, 2023; Saleh & Zeebaree, 2025) were included.

With regard to technology families, three were identified: first, those related to eye tracking (Almourad et al., 2025; Kemora et al., 2024; Kondak, 2023; Mashrur et al., 2022; Šola et al., 2024, 2025; Yüksel, 2023) to analyze user attention and optimize interface and content design. Second, neurophysiological biometrics (EEG, FER) to predict preferences or capture affective states (Ishtiaque et al., 2025; Mashrur et al., 2022; Saleh & Zeebaree, 2025); and, finally, voice analysis (multimodal biometrics) applied to conversational assistants and authentication (De Kloet & Yang, 2022; Gökhan & Aydin, 2022; Kaponis et al., 2024)

Regarding integration with Artificial Intelligence (AI), the paper describes the conceptual integration of AI for personalization and automation in immersive contexts (Gökhan & Aydin, 2022); AI applied to data analytics (Saleh & Zeebaree, 2025); machine learning models for classifying preferences based on EEG characteristics (Ishtiaque et al., 2025; Mashrur et al., 2022); the integration of AI and machine learning for real-time personalization, targeting, and optimization (Kaponis et al., 2024; Kemora et al., 2024); eye tracking (AOIs, fixations); AI applied to communication and analytics; neuromarketing (Kondak, 2023); eye tracking (Tobii X2-30); metrics for attention, clarity, and cognitive load; webcam-based eye tracking (Tobii Sticky); predictive modeling; and emotional analysis (Šola et al., 2024, 2025; Yüksel, 2023); voice analysis (conversational assistants) + biometrics (facial recognition) for multimodal authentication (De Kloet & Yang, 2022); and biometrics, through automatic facial expression analysis (FER) + implicit measures (IAT/BARTT) (Mauri et al., 2021). Table 2 shows the details of the selected studies.

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**Table 2.** *Description of the selected articles*

| Author, year, and country | Title | Design and metrics | Objective | Technology coverage – ethical aspects | Integration with AI | Methodology | Results | Conclusion |
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| Almourad et al., (2022) – United Kingdom | Strategic Placement of Branding Elements in Digital Marketing: Insights from Eye-Tracking Data | Experimental eye-tracking study (laboratory, HCI). Metrics including AOIs, fixations, and count were recorded | To examine natural gaze patterns to identify the optimal placement of branding elements and their relationship to processing fluency. | Eye tracking (AOIs, fixations). No specific ethical considerations reported. | No explicit use of AI algorithms in the analysis; neuromarketing framework. | N=83 students; 5-second exposure to advertising images; recorded with a Tobii eye tracker; fixation and count metrics; analysis by areas of interest. | Upper regions are identified as key focal points for the brand; fixation metrics support expected patterns of brand search. | Strategic placement improves brand recognition; instinctive gaze guides advertising design decisions. |
| Gökhan et al., (2023)—Turkey | Development and Transformation in Digital Marketing and Branding with Artificial Intelligence and Digital Technologies: Dynamics in the Metaverse Universe | Review/narrative (conceptual) article. Use case metrics and trends were documented. | Explores the influence of AI and digital technologies on marketing and branding, with a focus on the metaverse. | AI applications in marketing: voice and image recognition, chatbots, segmentation, privacy, and biometrics in the metaverse. Warns about privacy, security, and the use of biometrics. | Conceptual integration of AI for personalization and automation in immersive contexts. | Literature review and examples of AI in marketing and the metaverse; discussion of ethical and security implications. | Identifies case studies and trends (e.g., voice/face recognition, chatbots) and privacy risks associated with biometric data collection (eye movements, facial expressions) in immersive environments. | AI is reshaping the customer experience in the metaverse; a balance is needed between data tracking for personalization and privacy protection. |
| Ishtiaque et al., (2025) – Bangladesh | Machine learning-based prediction of viewers' preference | Experimental study using EEG and | To predict preferences for social awareness advertisements based | Neurophysiological biometrics (EEG). Ethical considerations are not | Machine learning models for classifying preferences | Emotiv Epoc X (14 channels); 8 videos (49±9 s) with humor/impac | The ML pipeline classifies ad preferences/ratings | The EEG+ML combination is viable for advertising |

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| | s for social awareness advertisements using EEG | machine learning. EEG metrics, engagement, and cognitive comfort were recorded. | on EEG signals and to identify neural markers linked to engagement and message comprehension. | explicitly mentioned. | based on EEG features. | t effects; ratings from 1 to 10; preprocessing (filters, notch filters, ICA, ASR), feature extraction, and classification. | using EEG; engagement and cognitive comfort markers linked to message effectiveness are reported. | personalization based on neural responses to public service announcements. |
| Kaponis et al., (2024) – Greece | Enhancing User Experiences in Digital Marketing through Machine Learning: Cases, Trends, and Challenges | Narrative review with case studies (not peer-reviewed). Metrics on cases, trends, and biases were documented. | Analyzes ML applications that personalize content and improve UX in digital marketing, considering ethical dimensions. | NLP/voice (voice search), recommendation systems, programmatic advertising, computer vision. Highlights risks of bias, echo chambers, and the need for transparency. | Extensive integration of AI/ML for personalization, targeting, and real-time optimization. | Analytical synthesis of literature and case studies; identification of trends and challenges (privacy, biases, explainability). | Describes the effects of ML on retention, recommendations, real-time bidding, and social listening; warns about echo chambers and biases. | AI-driven personalization must be balanced with transparency and data protection to maintain user trust. |
| Kemora (2024) – Finland | Optimizing Digital Marketing Efforts through Neuromarketing: A Systematic Literature Review | Systematic review (2021–2023) with thematic analysis. Neuro metrics (fixations, EEG, GSR response) were recorded. | Summarizes how neuromarketing techniques support personalization, UX, and advertising effectiveness in digital marketing. | Eye tracking, EEG, fMRI, GSR, facial coding; applications to social media and advertising. Highlights ethical challenges regarding biometric data. | Reports on the integration of ML/AI (e.g., neural networks) for ad segmentation and personalization. | Structured search; inclusion/exclusion criteria; data extraction and synthesis by topic (personalization, UX, ad effectiveness, decision-making). | Neurophysiological measures predict responses and enable the optimization of ad placement, creativity, and UX; validation of scales using biometrics. | Neuromarketing provides evidence for personalized and effective campaigns; it requires ethical and data-related considerations. |

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| De Kloet et al., (2022)—Netherlands | The Effects of Anthropomorphism and Multimodal Biometric Authentication on the User Experience of Voice Intelligence | Online between-subjects experiment (2×2 factorial design). Metrics for usability, perceived risk, and adoption were recorded. | To examine how anthropomorphism and multimodal biometric authentication influence the adoption and perception of voice intelligence within the customer value chain. | Voice analysis (conversational assistants) + biometrics (facial recognition) for multimodal authentication. Links personalization to biometric data security. | AI in smart voice (ASR/TTS/NLU) and biometric authentication for personalization and security. | N=240 (MTurk); 4 conditions (with/without anthropomorphism × with/without multimodal authentication); audio vignettes of interactions with an assistant; measures of utility, ease of use, risk, and adoption. | Positive and significant effect of anthropomorphism and multimodal authentication on adoption and overall perception; the effect of authentication ($\eta^2 \approx 0.11$) was greater than that of anthropomorphism ($\eta^2 \approx 0.05$). | The combination of anthropomorphic features and multimodal authentication enhances the willingness to adopt smart voice technology, with implications for secure, personalized experiences. |
| Kondak et al., (2023)—Turkey | The Application of Eye Tracking and Artificial Intelligence in Contemporary Marketing Communication Management | Mixed-methods study: systematic review + online content analysis + expert interviews + eye-tracking pilot study. Metrics including AOIs, fixations, and expert interviews were | Design a proposal for the synergistic use of eye tracking and AI in marketing communication management | Eye tracking (AOIs, fixations); AI applied to communication and analytics; neuromarketing. Warns about privacy and responsibility in its use. | Proposes ET+AI synergies for personalization, optimization, and analytics; emphasis on responsible use and privacy | SLR; content analysis; interviews; pilot study using Gazepoint GP3 and Gazepoint Analysis v6.9.0 software | Identifies the benefits, challenges, and potential of ET+AI integration; highlights the future of new technologies and the need for responsible use | Practical recommendations and research agenda; ET+AI integration can guide strategic decisions in marketing communication |

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| | | recorded | | | | | | |
| Mashrur et al., (2022) Bangladesh | An intelligent neuromarketing system for predicting consumers' future choices from electroencephalography signals | Experimental study using EEG and machine learning. EEG metrics and accuracy (98–99%) were recorded | Predicting future consumer preferences for e-commerce products based on EEG | Biometrics (EEG), (GSR, eye tracking, FER). Does not explicitly report ethical considerations. | Feature extraction; feature selection using SVM-RFE; classification using SVM | Dataset with 19 channels (10–20), product stimuli, 5-fold, 10-fold, and LOSO validations | High accuracy (≈98–99% in frontal regions; Fz stands out); feasibility with consumer-grade devices | EEG+ML enables the prediction of preferences with high accuracy, useful for personalization based on neurophysiological signals |
| Mauri et al., (2021) – Italy | Applying Implicit Association Test Techniques and Facial Expression Analyses in the Comparative Evaluation of Website User Experience | Online experiment (between-subjects) with pre-post measurements. Facial emotion metrics and implicit associations were recorded. Data governance, privacy. | To evaluate whether the IAT (BARTT) and facial expression analysis contribute to measuring web UX | Biometrics: automatic facial expression analysis (FER) + implicit measurement (IAT/BARTT). Ethical considerations are not mentioned. | Use of emotion recognition software and implicit association testing to infer affective responses | N ≈ 160; browsing of 2 automotive brand websites; FER for 3 min; IAT before/after; heuristic evaluation | Significant differences between sites in emotional responses; the IAT captures changes following navigation; correlation with heuristic evaluation | IAT + FER provide valid metrics for evaluating UX and the emotional impact of brand websites |

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| Saleh et al., (2025) – Iraq | Artificial Intelligence in E-commerce and Digital Marketing: A Systematic Review of Opportunities, Challenges, and Ethical Implications | Systematic review. Metrics related to data governance and privacy were recorded. | To synthesize opportunities, challenges, and ethical considerations of AI in e-commerce and digital marketing | AI applied to data analytics, personalization, and recommendation systems; mention of facial and sentiment analysis. Emphasizes privacy, bias, and transparency. | ML/DL for real-time segmentation, prediction, and personalization; discussion of data governance and privacy | Search and analysis of recent literature; open-review policy report | AI improves efficiency and personalization of the customer journey; gaps in privacy and scalability | Responsible AI adoption fosters long-term relationships and competitiveness; privacy, bias, and transparency must be addressed urgently |
| Šola et al., (2024) - Croatia | Predicting Behavior Patterns in Online and PDF Magazines with AI Eye-Tracking | Study applied with software for for based based on AIeye tracking, etc. Metrics for attention, engagement, clarity, and cognition were recorded | Improving magazine design and predicting reader behavior/attention | Eye tracking (Tobii X2-30); metrics for attention, engagement, clarity, and cognitive load. No explicit ethics statement provided. | Encoder–decoder model with a pre-trained encoder; reported accuracy of 97–99% | Analysis of 3 university journals; use of Predict v1.0 software; ANOVA and Welch's t-test | Predicts focal points of attention and engagement with high accuracy, guiding the optimization of the layout | AI-assisted eye tracking shows promise for designing clearer, more engaging and efficient content |
| Šola et al., (2025) – Croatia | AI and Eye Tracking Reveal the Impact of Design Elements on E-Magazine Reader Engagement | Experimental Eye Tracking (Tobii Sticky) + AI (Predict v1.0). Metrics for attention, clarity, | To analyze how design elements (content structure, background color) influence the engagement, attention, and emotional response of | Webcam-based eye tracking (Tobii Sticky), Predict software (AI eye tracking), emotional analysis. No mention of ethics; performance-focused use. | AI eye-tracking algorithms based on ConvNeXt and a neuromarketing dataset (n ≈ 180,000, multimodal EEG+ET). | 144 participants (Oxford Business College); tests using OxConnect magazine articles (HND vs. OxFoodbank), black-and-white versions; | The HND article generated greater sustained attention and more neutral/consistent emotional responses than OxFoodbank; a | The integration of AI eye tracking and neuromarketing optimizes the design of e-magazines to improve |

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| | | cognitive load, and emotions were recorded | e-magazine readers. | | | measures of attention (total, start, end), clarity, cognitive load, and emotions; analysis using Python and Predict. | white background produced greater sustained attention; AI+ET enabled the identification of significant differences in engagement and cognitive load. | engagement and information retention, even in the presence of background distractions. |
| Yüksel et al., (2023) – Turkey | Investigation of Web-Based Eye-Tracking System Performance under Different Lighting Conditions for Neuromarketing | Experimental study conducted in a controlled laboratory setting and under natural light. Metrics such as fixation accuracy and heat maps were recorded. | To evaluate how lighting conditions (type and direction) affect the performance of webcam-based eye-tracking systems applied to neuromarketing/e-commerce. | Webcam eye tracking (GazeRecorder); analysis of heat maps and fixation accuracy. No ethical considerations are reported. | Mentions the trend toward AI-driven eye-tracking software, but the experiment primarily used GazeRecorder (statistical). | 30 participants (ages 18–27); tests conducted under artificial lighting (softboxes) and natural lighting (window), with light coming from the right, left, or front; measurements of angular displacement and distance between the fixation point and the target. | Natural lighting increased accuracy by 24% compared to artificial lighting; frontal light produced better results than side lighting; the system's reliability depends on calibration and environmental conditions. | Web-based eye-tracking systems show promise for neuromarketing and e-commerce, but their performance is critically dependent on lighting; they must be optimized for complex interfaces. |

Compiled by the author based on the selected articles.

## Integration of Eye Tracking with AI for Design, Attention, and Engagement

Research analyzing eye tracking agrees that visual layout is crucial for capturing greater attention and ensuring users remember the brand; specifically, it was found that the central or upper region facilitates familiarity with brand elements. On the other hand, in the case of digital magazines, their structure, contrast, and the way content is organized influence the amount of attention the user devotes to them, as well as how long that

attention is sustained; similarly, this affects the clarity with which the user perceives the content they are consuming. In general, using a white background promotes more stable attention, resulting in more organized reading paths. Integration with AI models facilitates the prediction of points of attention and behavioral trends, as well as the guidance of design strategies regarding visual hierarchy or layout to achieve better brand recognition by the user (Almourad et al., 2025; Kemora et al., 2024; Kondak, 2023; Mashrur et al., 2022; Šola et al., 2024, 2025; Yüksel, 2023).

Integration of Neurophysiological Biometrics (EEG) + AI for Predicting Preferences

Regarding the articles that evaluated biometrics and its integration with AI to improve preference classification and estimate the type of user responses to online advertising material, they determined that accuracy is high after applying processing filters and extracting time and frequency features using algorithms such as SVM or multi-case pipelines. This research underscores that the use of this integration is viable and effective for personalizing advertising; at the same time, it allows for the classification of product options using electroencephalographic biomarkers, primarily in the frontal regions, which are associated with control and decision-making ability (Ishtiaque et al., 2025; Mashrur et al., 2022; Saleh & Zeebaree, 2025).

Integration of voice analysis and multimodal biometrics for personalized experiences

Articles that analyze the integration of voice analysis with AI—using conversational assistants through anthropomorphism and multimodal biometric authentication—are linked to an increase in customers' desire to learn more and help the product be perceived as safer and more useful; which indicates that the personalization of digital marketing products (voice commerce), based on integration with AI, is more effective when used in conjunction with strategies that increase user security and trust, thereby fostering customer loyalty as well as attracting new customers through voice-based journeys (De Kloet & Yang, 2022; Gökhan & Aydin, 2022; Kaponis et al., 2024).

In general, it was found that integrating these digital neuromarketing strategies with AI enables fine-grained segmentation and the targeting of advertising strategies; while also facilitating real-time ad personalization using biometric signals (eye tracking, voice analysis, physiological biometrics) to optimize the user experience (UX) and creative effectiveness; at the same time, they highlight the ethical considerations to keep in mind when using these integrations, taking into account privacy protection and AI biases; therefore, they suggest that frameworks should be established to define legal liability for their use, since they involve biometric information—particularly in immersive experiences, the metaverse, and voice and facial recognition tools (Gökhan & Aydin, 2022; Kaponis et al., 2024; Kemora et al., 2024; Kondak, 2023; Saleh & Zeebaree, 2025).

The purpose of this systematic review was to analyze the integration of eye-tracking, voice analysis, and physiological biometrics technologies with AI algorithms for the personalization of experiences in digital marketing. In general, the results of the reviewed literature indicate that this integration not only facilitates the personalization of digital advertising but also enables the prediction of attention levels, the anticipation of user

preferences, and the identification of affective and cognitive states; all of this facilitates the adaptation of content to the specific characteristics of the intended user. At the same time, this integration improves the efficiency of digital marketing strategies and increases user interaction and brand engagement (Almourad et al., 2025; De Kloet & Yang, 2022; Gökhan & Aydin, 2022; Ishtiaque et al., 2025; Kaponis et al., 2024; Kemora et al., 2024; Kondak, 2023; Mashrur et al., 2022; Mauri et al., 2021; Saleh & Zeebaree, 2025; Šola et al., 2024, 2025; Yüksel, 2023).

These findings are also supported by related studies conducted by the authors on the application of eye tracking in the field of advertising. Mendoza et al. (2025), when comparing digital and traditional advertising strategies, identified differences in consumers' gaze patterns, attention span, and emotional engagement, demonstrating that the effectiveness of advertising stimuli can vary depending on the medium used and the cultural context. Likewise, Mendoza et al. (2026) noted that visual elements capable of generating emotional responses capture more attention and promote brand recall, which reaffirms the value of eye tracking in understanding consumers' visual and emotional interaction with advertising stimuli.

This is supported by the findings of Rodrígues et al. (2025): this integrated methodology provides a more authentic representation of user preferences compared to conventional methods, which are often influenced by biases or social norms. By capturing objective behavioral and demographic indicators, the model offers reliable information that enables companies to optimize their product features, refine marketing campaigns, and effectively guide development initiatives. In a competitive market, the use of these technologies facilitates more informed decision-making and long-term strategic advantages.

This is also consistent with the findings of Sharakhina et al. (2024), who found that AI analysis allows for tracking the level of audience engagement with video content, thereby helping to improve communication effectiveness. This promotes the use of AI to generate recommendations for developing more targeted and compelling advertising messages.

According to Thakur & Pasha (2024), neuromarketing analysis improves substantially through the integration of AI, thanks to the use of advanced algorithms. AI algorithms and modern technological tools enable organizations to process large and comprehensive data sets, providing immediate insight into consumers' subconscious reactions to advertising content. Through facial recognition, eye-tracking, and sentiment analysis techniques, marketing strategies benefit from dynamic improvements that translate into better results.

Regarding eye tracking, Micu et al. (2021) established that it is one of the most effective tools in neuromarketing, provided it is used with reliable participants, as it allows for the recording and analysis of eye movement using infrared light that identifies the position of the pupil. While the user is exposed to various stimuli, the eye tracker recognizes gaze patterns that suggest attention and interest. This technique is used in

neuromarketing to measure user interaction with advertisements and thus identify the factors that convert visitors into customers, because, with the rise in advertising saturation, it has become more difficult to capture the customer's attention and pique their curiosity.

In a recent systematic review, Mubarok et al. (2025) support the findings of this review and provide a comparison of the use of AI integration in developed and developing countries. According to the cited authors, developed countries leverage AI for content personalization, predictive analytics, and marketing automation, supported by an advanced digital infrastructure; whereas in low-resource settings, limitations still exist in this regard, attributable to limited infrastructure and digital literacy.

Furthermore, the findings of Islam et al. (2024) are also consistent with those of this systematic review; these authors determined that AI integration enhances digital marketing by optimizing processes, automating repetitive tasks, and delivering hyper-personalized customer experiences; moreover, its predictive power helps anticipate consumer behavior, while chatbots improve real-time customer interaction. However, the cited authors acknowledge that challenges persist, such as data privacy, algorithmic bias, and the high costs of AI adoption. AI enables companies to make data-driven decisions, improve customer retention, and maximize return on investment.

Furthermore, Deckker & Sumanasekara (2025), in another systematic review, also concur with the findings of this study. According to these authors, neuromarketing techniques that utilize AI have proven to be highly effective in analyzing consumers' subconscious responses, tailoring advertising content, and personalizing marketing strategies. Thanks to AI's capabilities in deep learning, machine learning, and biometric data analysis, all subconscious decision-making mechanisms enrich traditional models of consumer behavior. However, this advancement raises significant ethical concerns regarding transparency, privacy, and data security. It is necessary to develop a robust ethical framework for the use of AI in business to ensure its responsible implementation, given its potential for algorithmic bias, abuse of hyper-personalized marketing, and many other factors.

Regarding the ethical challenge posed by the integration of AI into digital neuromarketing, the findings of this review align with those of Sposini (2024), which highlight the importance of rethinking the legal framework for the use of AI in neuromarketing, given the use of biometric information related to consumers' emotions and moods; therefore, oversight of the processing and use of biometric data must be strengthened to ensure the ethical use of AI in this context.

## CONCLUSIONS

The integration of technologies such as eye tracking, voice analysis, and biometrics with AI yields favorable results in the hyper-personalization of the digital marketing experience.

This integration facilitates the prediction of attention patterns and brand recognition, and can increase customers' perception of trust and the emotional impact of digital marketing.
Furthermore, it increases the accuracy of identifying emotional responses and preferences, which serves as the starting point for proper segmentation of advertising campaigns.
Despite these advantages, the literature emphasizes the importance of the ethical use of users' biometric data, for which up-to-date legislation consistent with this purpose is essential.

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