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Gaze Matters: A Systematic Review of Eye Tracking Applications in Visual Communication Design

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ABSTRACT

The advancements in eye tracking technology have undergone substantial development within the realm of visual communication design, leading to the emergence of diverse study methodologies and fragmented empirical observations. Despite the large body of research conducted on this topic, there exists a notable deficiency in the thorough integration of these various methodologies, impeding the establishment of a unified comprehension of the field. This review aims to address the existing knowledge gap by consolidating the various research methodologies employed in the domain of eye tracking in visual communication design. The objective is to offer a more comprehensive understanding for both researchers and practitioners. A comprehensive evaluation was conducted on a total of 402 articles published between 2014 and 2023, resulting in the selection of 34 articles for inclusion in the study. The publications were primarily sourced from respected academic databases such as Scopus, ERIC, and JSTOR. A comprehensive record of the primary components of each publication, encompassing the objectives, methods, and outcomes, was meticulously documented within a matrix composed of tables. The review provides a comprehensive examination of the extensive range of applications of eye tracking techniques in studying visual attention, design impact, usability, and user interactions across diverse communication contexts. Furthermore, the identification of potential areas for future research in the discipline was also emphasised. This systematic review elucidates the complex interplay between eye tracking and visual design throughout the last ten years. The utilisation of a structured matrix facilitates the reader's ability to effectively navigate the extensive array of methodologies, conclusions, and implications within this interdisciplinary field. This approach enhances the comprehension and practical application of the gathered knowledge.

1. Introduction

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The emergence of eye tracking technology has brought about significant changes in the field of visual communication design, revealing complex cognitive processes and behavioural patterns of individuals as they engage with visual content. This technology serves as a means of bridging the aspirations of designers with the innate responses of their audience through the precise tracking of gaze trajectories and fixation durations [1,2]. The integration of technology innovation and psychological insights provides designers with a strong empirical basis for their ideas. In the contemporary era of digital technology, it is crucial to determine the primary focus of a viewer's attention and the length of their involvement. In the middle of a vast array of visual stimuli, encompassing both digital and physical realms, designers face the challenge of creating content that effectively engages and captivates their target audience. Eye tracking is a highly accurate tool in this particular context. Not only does it accurately identify the location where individuals' eyes fixate, but it also systematically tracks the sequence of visual attention and identifies regions that receive significant focus or are overlooked.

Technology plays a crucial role in facilitating the assessment of the final design, supporting the use of iterative design methodologies that enable professionals to enhance their work for optimal effectiveness [3]. The exploration of eye movement analysis provides designers with valuable insights into human visual behaviour, enabling them to refine designs across many mediums such as web page layouts, intricate infographics, and harmonious multimedia content. The increasing number of applications for eye tracking highlights its significant significance in shaping the future of visual communication design, which cannot be denied. Eye tracking has significantly enhanced our understanding of viewer engagement in the field of visual communication. The essential factors influencing perception, focus, and retention have been elucidated. Research, particularly in the field of health communication, emphasises the utmost importance of design excellence. The attainment of a certain level of design excellence corresponds to the highest degree of spectator engagement [4]. The concept of maintaining a delicate equilibrium between simplicity and complexity is a fundamental principle that can be applied to various forms of visual communication.

The significance of narrative and context in design is underscored by the presence of autism spectrum disorder (ASD) in children. Both children with autism spectrum disorder (ASD) and typically developing youngsters demonstrate a preference for static pictures that incorporate storytelling aspects. However, it appears that the latter group finds dynamic content, such as videos, to be more appealing [5]. The differentiation between these two concepts is of utmost importance for educators who are developing customised educational materials. Design reviews of Augmentative and Alternative Communication (AAC) emphasise the effectiveness of colour-coded symbols, particularly when targeting younger individuals. These findings support the use of intuitive design principles, particularly when designing for audiences with communication difficulties.

Attention dynamics are emphasised in educational domains. In the field of chemistry education, the utilisation of dynamic cues in instructional videos serves the purpose of capturing and maintaining attention, while also enhancing the retention of information by reducing cognitive load [6]. The impact of visual components on student attentiveness has been investigated in platforms such as CGTN's mobile learning, highlighting the significance of inventive typography in the dissemination of information. Brands strategically handle the dynamic and always-shifting digital landscape. The increasing preference for minimalist logos among young individuals suggests a shift in aesthetic preferences, potentially influenced by the widespread presence of digital media [7]. Organisations should exercise discretion when utilising animations and icons, taking into consideration the potential hazards of visual overload that may hinder effective communication. The phenomenon of attention dynamics is also prominently observed in the realm of advertising. The incorporation of Intelligent Bounding Boxes (IBBs) into the framework of the Dynamic Human-

Centred Communication Systems Theory provides a clearer understanding that the allocation of significance to dynamic stimuli mirrors interactions observed in real-life situations [8]. Advertisers have the ability to utilise these insights in order to enhance levels of engagement.

The objective of this study was to investigate the relationship between geography learning and visual abilities, with the ultimate goal of designing a geography textbook that enhances visual representation [9]. This undertaking highlights the potential of eye tracking technology in enhancing instructional information, by matching it with natural patterns of visual engagement.

The significance of structural configuration and design component aggregation in determining user choices and involvement is emphasised by digital interfaces. The preferences of millennials are substantially influenced by design aspects, photo volume, and search tool placements on platforms such as booking.com and hoteles.com [10]. The utilisation of complimentary colours in labels within map legibility studies has a significant impact on visual attention, as evidenced by the interplay between colour shifts, reaction times, and durations of fixations. The prevalence of social media as a contemporary means of communication necessitates the exploration of eye tracking studies. The investigation conducted on health-related information disseminated on Facebook has shed light on the significant impact of integrated text pictures in enhancing user engagement and retention. Graphics, as opposed to photographs, have the ability to attract a broader audience, emphasising their importance in health communication on platforms such as these [11]. The animation levels of sponsorship signs in sports broadcasts display a range of variations that have an impact on the focus of viewers [12].

The findings of the research indicate that the utilisation of advanced animation techniques has the potential to enhance levels of attention without compromising the clarity of the information being presented. This hints at potential opportunities to augment sponsorship communication in subsequent broadcasts. In conclusion, the utilisation of eye tracking studies in various aspects of visual communication design reveals identifiable trends. The essence of visual communication encompasses various domains, including but not limited to health, instructional design, branding, and computer interfaces. This endeavour entails the integration of design aspects, understanding interactions with the target audience, and continuously improving methods based on empirical evidence. The utilisation of a structured matrix facilitates the proficient navigation and correlation of procedures, outputs, and analyses within research, hence enhancing comprehension and the practical application of data.

2. Methodology

2.1 Identification

To select suitable papers for this report, a systematic review process was deployed, comprising three fundamental stages. The initial stage entailed recognizing keywords and seeking synonymous or related terms from resources like thesauri, dictionaries, encyclopaedias, and prior research. Once essential keywords were finalized, specific search criteria were established for databases such as Scopus, ERIC, and JSTOR, as depicted in Table 1. Through this strategy, the review efficiently sourced 402 articles from these databases.

The subsequent stage, the identification phase, focused on unearthing studies that aligned with the present research topic. Central to this were the keywords: eye tracking, visual communication, and design. This involved pinpointing these terms and finding related or comparable terms from past studies. Consequently, after collating all pertinent terms, search guidelines tailored for the Scopus and ERIC databases were crafted, referenced in Table 1. Using this refined search approach, the research successfully amassed 191 papers from the databases.

Table 1
Illustrates the research databases and keywords searching for the study

Scopus	TITLE-ABS-KEY "eye tracking" OR "eye-tracking" AND visual AND communication AND design AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))
ERIC	"eye tracking" OR "eye-tracking" AND visual AND communication AND design
JSTOR	"eye tracking" OR "eye-tracking" AND visual AND communication AND design

2.2 Screening

During the initial screening phase, duplicate articles were removed. The first round led to the removal of 115 papers, while 81 articles were filtered out in the second round, adhering to specific inclusion and exclusion criteria set by the researchers. Emphasis was placed on research articles as they serve as principal sources of actionable information. This resulted in the exclusion of other forms of publications such as systematic reviews, general reviews, meta-analyses, meta-syntheses, book series, individual books, chapters, and conference proceedings. Additionally, the review was narrowed down to papers published in English only. The selected timeframe spanned a decade, from 2014 to 2023 (refer to Table 2). Ultimately, a total of 368 articles were discarded based on these criteria.

Table 2
The selection criterion involves the process of doing a search

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2014 – 2023	< 2014
Literature type	Journal (only research article)	Conference, Book, Review
Publication Stage	Final	In Press

2.3 Data Abstraction and Analysis

In this study, an integrative analysis was utilized as one of the evaluation techniques to review and amalgamate diverse research methodologies, including quantitative, qualitative, and mixed methods. The proficiency research aimed to extract study specifics such as the author's name, year of publication, journal source, and title. Constructing the content for the table matrix began with the data collection phase. Figure 1 on the subsequent page illustrates the systematic scrutiny of 402 articles by the researchers to identify content pertinent to the study's objectives. The researchers then delved into the most recent pivotal articles focusing on eye tracking applications, visual communication, and design, exploring both their methodologies and results. Subsequently, the main author collaborated with co-authors to develop a table matrix from the data, aiming to pinpoint validity concerns. The stage of expert review underpins the lucidity, relevance, and aptness of each subtheme by defining its scope.

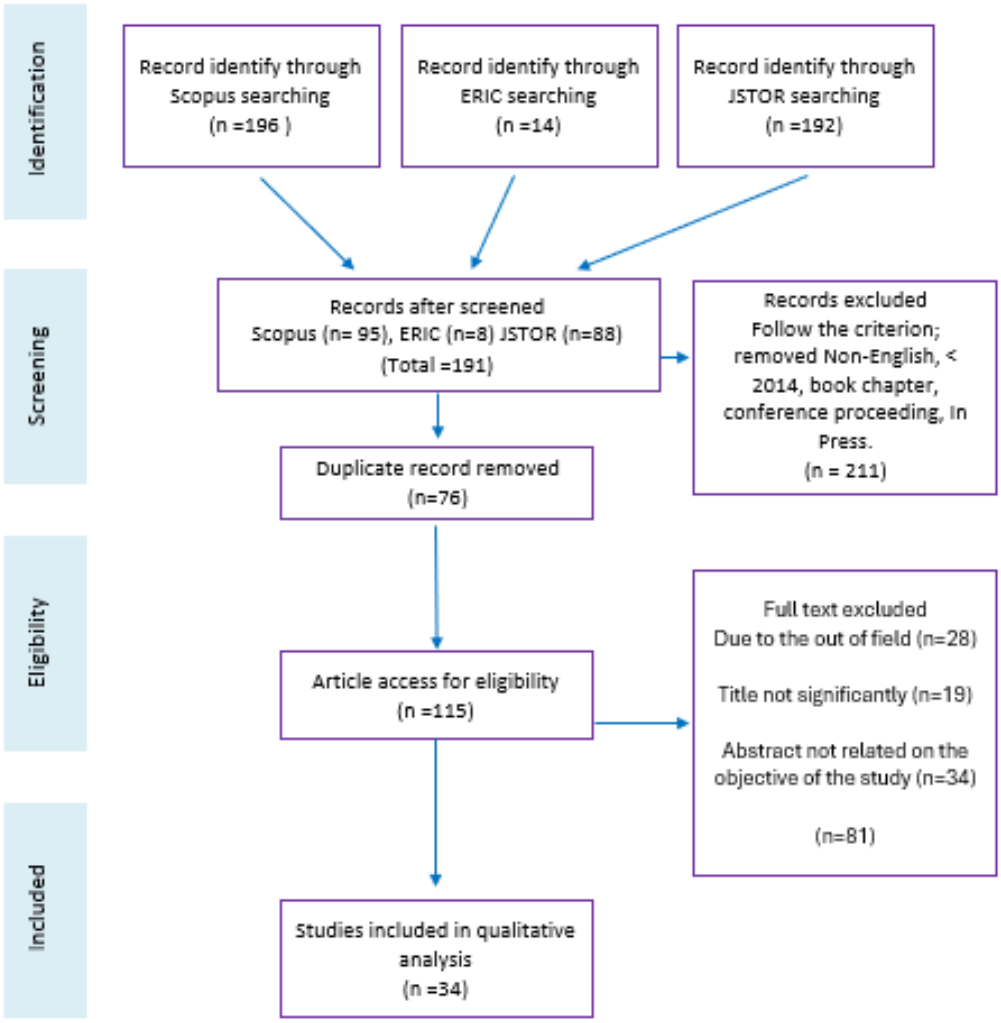

Fig. 1. The PRISMA flow diagram represents the information flow through the different phases of a systematic review [1]

3. Results and Finding

In the SLR paper, employing a table matrix offers an organized and succinct way to showcase findings from chosen studies (refer to Table 3 on the next page). This matrix assists readers in rapidly grasping and contrasting the studies' features, methodologies, outcomes, and pertinent data. It encompasses everything from basic study details like authors, publication year, title, and source, to more in-depth information like research focus, methodology used, variables, results, conclusions drawn, practical implications, study limitations, and prospects for future research.

Table 3
The research's key aspects, including objectives, methods, and findings, were systematically captured in the table matrix below

Author/Year/ Journal	Title	Abstract	Methodology
Kanazawa F. *et al.,* [2] *Journal of Destination Marketing and Management*	Destination website management: A social constructionist approach	In a study with university students, dynamic signals in instructional videos enhanced focus, improved retention, reduced cognitive load, highlighting the value of integrating signalling and temporal contiguity	Methodology: Employed exploratory qualitative research. Utilised a multi-method design for comprehensive insights. Participants: Analysed visual attention of 28 chemistry participants. Participants were exchange students in Brazil. Tools & Procedure: Eye tracking technology is used to assess visual attention on a destination website. Conducted follow-up in-depth interviews to understand perceptions of website management elements. Outcome: Developed a social constructionist model for destination websites. Provided managerial suggestions to enhance country brand digital strategies.
Wilkinson K., Zimmerman T., Light J. [3] *Journal of Speech, Language, and Hearing Research*	Visual attention to cued targets in simulated aided augmentative and alternative communication displays for individuals with intellectual and developmental disabilities	The study used eye tracking to assess how individuals with disabilities reacted to AAC display prompts. Post-audio cue, participants notably focused on specific VSDs, underscoring design implications.	Objective: Assess visual-perceptual processing in individuals with disabilities using AAC systems via eye tracking. Participants: Autism (n=13), Down syndrome (n=13), Intellectual disabilities (n=9), Typical development (n=20). Procedure: Participants, guided by a spoken prompt, located a navigation key in an AAC display with eye tracking technology. Measurements: Fixation duration on target VSD post-cue compared to other VSDs.

Liang, J., Wilkinson, K. [4] *Journal of Speech, Language, and Hearing Research*	Gaze toward naturalistic social scenes by individuals with intellectual and developmental disabilities: Implications for augmentative and alternative communication designs	Using eye tracking, researchers studied responses to photos with 2 or 3 figures sharing activities among autism, typical development, and Down syndrome individuals. Autism showed a slower gaze with three figures, advocating varied social content in visuals.	Objective: Examine the impact of human figures and sharing activities in photos on visual attention in individuals with autism, typical development, and Down syndrome, focusing on visual scene displays. Tool: Eye tracking technology. Participants: Individuals across three groups. Procedure: Participants viewed 32 photos with varied human figures (2 or 3) and activities (sharing present or not). Measurements: Latency to view figures and fixation duration, analysing differences based on figure count and depicted activities. Factors: Number of figures (2 or 3); presence of sharing activities.
You, H *et al.,* [5] *IEEE Micro*	EyeCoD: Eye Tracking System Acceleration via FlatCam-Based Algorithm and Hardware Co-Design	EyeCoD is a compact, lens less eye tracking system tailored for AR/VR, outperforming bulky traditional systems. Its efficiency and accuracy promise advancements in AR/VR eye tracking and enhanced imaging systems.	Objective: Designing and developing a lens less eye tracking system named EyeCoD specifically for AR/VR applications. Methodology: Co-designing the system by integrating a unique camera setup, specialized algorithms, and accelerators. Implementing methods at the system, algorithm, and accelerator levels to boost system efficiency. Findings: Ensuring the system meets high throughput requirements (e.g., over 240 frames per second) and maintains a small form factor without compromising on eye tracking accuracy.

Choi, K., Suk H. [6] *Color Research and Application*	Optimal employment of color attributes to achieve saliency in icon matrix designs	Eye tracking identified warm, high-saturation colours, especially against black, as most attention-grabbing on smart device displays. High contrast improved visibility, guiding electronic interface design.	Objective: Determine attention-grabbing colours on displays for improved design. Tool: eye tracking, 21 hues were analysed for saliency. Results: Warm, high-saturation colours, especially against black, were most noticeable. High contrast combinations were most attention-catching. These findings aid in refining electronic interface design, enhancing aesthetics and communication.
Calvo, L *et al.,* [7] *Bulletin of the American Meteorological Society*	Users' Cognitive Load: A Key Aspect to Successfully Communicate Visual Climate Information	This study uses cognitive psychology to improve wind energy data visualization tools, enhancing user experience, decision-making, and quicker communication through user-cantered design.	Objective: to improve wind energy data visualization tools using cognitive psychology Methodology: user-centred design, cognitive psychology, and interaction techniques, this study revamped a wind energy climate service tool. Evaluating how alterations in visual encoding and interactive elements influenced response times, task success, and decision-making processes. Findings: The redesign's effect on user experience was measured using quantitative metrics like response time and eye tracking, along with qualitative feedback.
Wojdynski, B., Bang, H. [8] *Behaviour and Information Technology*	Distraction effects of contextual advertising on online news processing: an eye-tracking study	Using eye tracking, the study found that relevant ads boosted persuasion for weaker arguments, heightened attention, and emphasized strong content, influencing online publishing and visual attention theories.	Objective: Investigate the effect of editorial-ad congruency on users' content processing. Design: A 2x2 factorial experiment, manipulating message strength, and ad relevance Participants: 99 individuals. Material: News article about texting while driving risks. Measures: Attention to the article and ads and article persuasion. Data Collection: Eye tracking measured visual attention.

Cuesta-Cambra, U., Nino-González, J. Rodríguez-Terceno, J. [9] *Comunicar*	The cognitive processing of an educational app with electroencephalogram and "eye tracking"	Using eye tracking and EEG, the study explored attention in educational apps. Results indicated gender differences in attention but consistent recall. Simple, emotional images were best remembered, influencing app design recommendations.	Objective: Investigate students' information processing and learning in educational apps, focusing on gender disparities. Stimuli/ participants: 15 expert-rated images/ 22 students. Tools: Eye tracking, EEG, recall test, liking evaluation. Measures: Visual attention, memory, emotional value, EEG cognitive responses. Analysis: Evaluated attention, image recall based on attributes, EEG outcomes, and gender variations. Findings: User behaviours in apps mirror advertising reactions. Insights provided for app design improvement.
Wilkinson, K., Madel, M. [10] *American Journal of Speech-Language Pathology*	Eye tracking measures reveal how changes in the design of displays for augmentative and alternative communication influence visual search in individuals with down syndrome or autism spectrum disorder	The study examined if colour-clustering symbols, beneficial for typical children, influenced visual patterns of individuals with Down syndrome or autism. Eye tracking showed faster target identification and fewer distractions with colour-clustering.	Objective: Investigate how slight reorganization of a communication display impacts visual search patterns in individuals with Down syndrome or autism via eye tracking. Background: Earlier, colour-clustering symbols enhanced search in typical children. Participants: Those with Down syndrome or autism. Procedure: Participants conducted a visual search on an eye-tracked monitor. Measurements: Fixation speed, selection time, distracter fixation likelihood. Conditions: Comparison of clustered vs. non-clustered like-coloured symbols.

Eisma Y. *et al.,* [11] *Human Factors*	Augmented Visual Feedback: Cure or Distraction?	The study used eye tracking to assess how the "solution space diagram" (SSD) feedback affected workload and attention in aircraft conflict detection. While SSD improved detection, it led to misunderstandings and over-focus, suggesting careful implementation in human-machine interfaces.	Objective: Examine augmented feedback on workload, performance, and attention. Background: Emphasis on "solution space diagram" (SSD) indicating potential aircraft conflicts. Participants: Novices divided into two groups. Methodology: Both groups tackled conflict detection; eye tracking tracked attention. Metrics: Task challenge, detection accuracy, false positives, and SSD focus duration. Findings: Evaluated performance and attention differences between groups, assessing SSD's impact. Significance: SSD can streamline tasks, but may lead to visual tunnelling and misconceptions.
Pozharliev, R. Rossi, D., De Angelis, M. [12] *Psychology and Marketing*	A picture says more than a thousand words: Using consumer neuroscience to study Instagram users' responses to influencer advertising	The study used eye tracking and EEG to see how influencer size and argument quality affect consumer reactions. Micro-influencers garnered more attention with weak arguments, influencing the behavioural activation system, guiding Instagram marketing strategies.	Objective: Assess the impact of influencer type and argument quality on viewer engagement with product-use photos on platforms like Instagram. Participants: 109 individuals in a lab setting. Methods: Eye tracking and EEG measured attention and brain responses. Design: 2x2 between-subject considering influencer size, and argument strength. Analysis: Mediated moderated linear regression. Focus: Understanding attention, especially fixations on influencer photos, and engagement in response to post strength and influencer type.

Li, W. *et al.,* [13] *Journal of Aeronautics, Astronautics and Aviation*	Touchscreen Controls for Future Flight Deck Design: Investigating Visual Parameters on Human-Computer Interactions between Pilot Flying and Pilot Monitoring	The study observed 12 experienced pilots using touchscreen controls on flight decks via simulation and eye tracking. Differences in attention between pilot flying and monitoring roles were noted, suggesting touchscreens may streamline future flight deck designs.	Objective: Investigate visual interactions of pilots (PF and PM) with touchscreen flight controls. Participants: Twelve seasoned pilots (average experience) Tools: Future Systems Simulator with touchscreen, Eye Tracker, SUS questionnaire. Procedure: Pilots conducted an instrument landing, alternating between PF and PM roles. Metrics: AOIs fixation counts; SUS usability evaluations. Analysis: ANOVA; t-test vs. PM SUS results. Outcome: Touchscreens offer opportunities to refine human-focused flight deck designs.
Ragazou, V. Karasavvidis, I. [14] *Interactive Technology and Smart Education*	Considering visual cueing and practice type for software training's optimisation: a study of domain experts	The study examined visual cueing (VC) and stepwise viewing-based practice (SVBP) in software tutorials. Neither impacted performance, but both boosted motivations. Recommendations include user-pausing and immediate feedback.	Objective: Investigate visual cueing and practice types in software video tutorials' impact on performance and motivation. Participants: 118 Computer Science undergraduates. Materials: Three video tutorials. Design: 2x2 mixed factorial. Analysis: Assessed variable relationships within design. Results: VC and stepwise viewing enhanced motivation, not performance. Recommendations: Employ eye tracking; offer immediate feedback. Implications/ Uniqueness: For expert learners, user-controlled pausing may boost retention. First study analysing VC and practice methods in expert software training.

Monteiro, P., Guerreiro, J., Loureiro, S. [15] *International Journal of Wine Business Research*	Understanding the role of visual attention on wines' purchase intention: an eye tracking study	In Portugal, a study using eye tracking revealed wine label attention influences purchase decisions, especially for award-winning wines or those for social events, informing wine marketing strategies.	Study Design: Utilized a 2x2 within-subjects design. Variables Examined: Effects of award status (awarded/not awarded), and consumption intent (personal vs. social) on wine purchase decisions. Methodology: 36 participants. Used eye tracking to monitor attention to wine labels. A questionnaire captured participants' perceptions of quality, preferences, and buying intentions. Research Focus: Assessment of how awards and consumption contexts influenced the relationship between visual attention to labels and purchase intent.
Peters, B. *et al.,* [16] *Frontiers in Human Neuroscience*	SSVEP BCI and Eye Tracking Use by Individuals with Late-Stage ALS and Visual Impairments	The study evaluated the Shuffle Speller interface for ALS patients using eye tracking and SSVEP BCI. Results indicated its potential, advocating further BCI improvements.	Objective: Assess typing systems for late-stage ALS patients with limited movement and vision. Participants: Two ALS patients. Design: Single-case experimental evaluation. Procedure: Three typing systems tested: standard eye tracking, Shuffle Speller with eye tracking, and Shuffle Speller with SSVEP BCI. Measurement: Typing accuracy was primary metric. Conclusion: Shuffle Speller, especially with BCI, offers significant potential for ALS communication; further development needed.

Boscolo, J. *et al.,* [17] *Marketing Intelligence and Planning*	Gender differences: visual attention and attitude toward advertisements	The study analysed gender-based differences in ad perception among Brazilian students using eye tracking. Males and females varied in visual attention and attitudes, with cultural and brand familiarity influencing outcomes.	Methodology: The study used an experimental design. Tools Employed: Questionnaire for data collection. Six print ads (male, female, or neutral-themed). Eye tracking with Tobii Studio software for visual attention analysis. Participants: 180 Brazilian public university students. Process: Students viewed the ads, with eye tracking measuring visual attention. They completed the questionnaire assessing ad attitudes. Variables: Independent: Ad type (male, female, neutral). Dependent: Visual attention and ad attitudes. Limitations: Specific focus on Latin consumers. Potential biases from familiar brand images in ads.
Champlin S. *et al.,* [18] *Journal of Communication in Healthcare*	Perceptions of design quality: An eye tracking study of attention and appeal in health advertisements	The study defines "design quality" combining visuals and design principles. Eye tracking showed health ads with moderate design quality received optimal responses, emphasizing its importance in health materials.	Tools: Eye tracking measured attention. Procedure: Participants viewed health ads with different design qualities, then evaluated them on attitude, comprehension, and effectiveness. Variables: Independent: Design quality levels (low, mid, high). Dependent: Attention and evaluation metrics. Findings: Mid-level design quality ads garnered the best evaluations. Attention peaked for mid and high-quality designs. Conclusion: There is an optimal design quality for health materials, underscoring the importance of design in health communications.

Ogle, A. *et al.,* [19] *Journal of the Academy of Nutrition and Dietetics*	Influence of Cartoon Media Characters on Children's Attention to and Preference for Food and Beverage Products	The study examined whether media characters on healthy food packaging affected choices of children. While characters enhanced attention, they did not consistently sway healthier preferences, especially among younger boys.	Objective: Determine media characters' influence on children's food preferences and demographic effects on choices. Participants: 149 children (6-9 years) from Twin Cities, MN. Method: Children viewed 60 pairs of healthier and less-healthy food products on computers, some featuring media characters. Measurement: Eye tracking monitored attention; participants selected preferred products. Analysis: Paired-samples, single-sample t tests and ANOVA
Tang, W., Fong, K., Chung, R. [20] *Journal of Autism and Developmental Disorders*	The Effects of Storytelling with or Without Social Contextual Information Regarding Eye Gaze and Visual Attention in Children with Autistic Spectrum Disorder and Typical Development: A Randomized, Controlled Eye-Tracking Study	This study used eye tracking to analyse how storytelling, with or without social context, affects gaze patterns of children with autism (ASD) and typical development (TD). After group training sessions, findings showed both groups benefited from contextual storytelling in static images, but only TD children did in videos.	Objective: Examine how storytelling, with or without social context, impacts eye gaze patterns in children with autism spectrum disorder (ASD) and Typical Development (TD). Participants: ASD and TD children. Design: Random assignment to two groups: Stories with social context. Stories without social context. Training: Eight 30-minute sessions over four weeks where children heard stories. Tools: Eye tracking assessed: Fixation, visit and fixation counts. Focus: Gaze patterns on faces in 20 pictures and a video. Analysis: Compared gaze patterns between storytelling methods, emphasizing facial/eye attention in photos and videos.

Wilkinson, K., O'Neill, T., McIlvane, W. [21] *Journal of Speech, Language, and Hearing Research*	Eye-tracking measures reveal how changes in the design of aided AAC displays influence the efficiency of locating symbols by school-age children without disabilities	Using eye tracking, the study analysed how AAC display designs influence children's visual search efficiency. Distributed symbols led to longer searches and more distractions than clustered symbols, underscoring the importance of distraction-minimized designs for communication-impaired individuals.	Objective: To determine how symbol organization on AAC displays influences children's response speed and accuracy. Participants: Children without disabilities. Methodology: Using eye tracking, participants performed a visual search on two AAC displays: one where like-coloured symbols were clustered and another where they were scattered. Results: Scattered symbols led to longer focus times and increased distractions. Conclusion: Efficient AAC design should minimize distractions, especially for users with disabilities.
Rodemer, M. *et al.,* [22] *Applied Cognitive Psychology*	Dynamic signals in instructional videos support students to navigate through complex representations: An eye tracking study	An eye tracking study of chemistry students revealed that dynamic signals in instructional videos improved focus, retention, and reduced cognitive load, underscoring the value of integrating signalling with temporal contiguity for optimal learning.	Participants: 28 chemistry undergraduates. Methodology: Students watched videos on reaction mechanisms under varied signalling conditions. Eye tracking monitored their gaze, while cognitive load and retention performance were assessed. Design: A within-subject approach ensured each student experienced all conditions. Results: Dynamic signals optimized attention to pertinent content. Improved retention was noted with dynamic signals. Dynamic signals lowered cognitive load. Conclusion: Dynamic signals in videos enhance student comprehension and learning by combining signalling and temporal contiguity principles.

Klein, E. *et al.,* [23] Journal of Health Communication	When Social Media Images and Messages Don't Match: Attention to Text versus Imagery to Effectively Convey Safety Information on social media	Study with parents used eye tracking to analyse attention on safety posts with matched/unmatched text and images on social media. Matched posts received more attention, enhancing safety knowledge.	Objective: Examine social media's influence on health behaviour using social cognitive theory. Participants: 150 parents. Method: Parents viewed real-world child safety posts with either matched or unmatched text and images. Measurement: Eye tracking monitored visual attention; post-viewing survey assessed safety recommendation recall. Analysis: Matched posts received more attention and were linked to better knowledge. Social media usage frequency and health literacy were also factors in outcomes.
Borowiak, K., Schelinski, S., von Kriegstein, K. [24] *NeuroImage: Clinical*	Recognizing visual speech: Reduced responses in visual-movement regions, but not other speech regions in autism	Individuals with autism (ASD) face challenges in visual-speech recognition. An fMRI study showed decreased brain responses in visual-movement areas during visual-speech tasks compared to controls, indicating sensory, not cognitive, processing issues in ASD.	Objective: Investigate brain's contribution to visual-speech deficits in autism spectrum disorders (ASD). Participants: 17 high-functioning ASD adults, 17 controls. Procedure: fMRI measured brain activity during visual-speech tasks, and eye tracking. Task: Observe facial movements conveying speech. Measurements: Brain activity (BOLD response), emphasis on right V5/MT and left TVSA, correlation between V5/MT BOLD and task performance. Findings: Distinct brain activity and connectivity differences between ASD and controls during tasks.

Bashirzadeh, Y., Mai, R. Faure, C. [25] *International Journal of Research in Marketing*	How rich is too rich? Visual design elements in digital marketing communications	Digital messages blending animations and pictographs can seem cluttered, increasing unsubscriptions and reducing in-app engagement, per a field study. Additional research examined visual processing and diversity.	Objective: Investigate how merging animations (GIFs) and pictographs (emojis) affects digital communication. Hypothesis: Joint use might create perceived clutter, undermining individual advantages. Method: Participants interacted with varied message setups in a mobile app experiment. Lab studies examined text/visual interactions, including eye tracking. Online experiments assessed visual quantity and emoji types. Message outcomes from different setups were compared. Conclusions: Derived from collective experiment data.
Wooley, B. *et al.,* [26] European Journal of Marketing	Influence of dynamic content on visual attention during video advertisements	This study employs eye tracking and Intelligent Bounding Boxes (IBBs) to evaluate attention in dynamic ads, revealing IBBs' potential by mimicking real-life viewer experiences.	Theory Tested: The study tested the Dynamic Human-Centred Communication Systems Theory using eye tracking. Methodology: Participants viewed unfamiliar video ads, with Intelligent Bounding Boxes (IBBs) tracking attention to moving segments. Analysis Approach: Analysis incorporated both static salience and dynamic attention parameters. Key Findings: Despite sample size constraints, results emphasized dynamic attention theory's relevance and the potential of IBBs in ad research.

Zhu, T., Yang, Y. [27] *PLoS ONE*	Research on mobile learning platform interface design based on college students' visual attention characteristics	Using eye tracking, the study assessed college students' focus on CGTN's mobile learning interfaces. Results underscored colour, text, and typography's influence on attention, spotlighting innovative typography's importance in communication.	Objective: Explore college students' visual attention on mobile learning interfaces to inform design. Tool: Head-mounted eye trackers. Sample: 28 images from 6 CGTN learning platform elements. Data Collection: Recorded eye movements during navigation. Analysis: Evaluated metrics such as attention duration, frequency, and visual recall, targeting $p<0.001$ significance. Conclusions: Colour, text, typography, and layout greatly influence attention, providing design guidance for improved visual engagement.
Behnke, Y. [28] *European Journal of Geography*	Visual qualities of future geography textbooks	The study connects visual skills with geography learning. Using eye tracking on German students and analysing European textbooks, it aims for an optimized geography textbook design.	Textbook Analysis: The study analysed 56 geography textbooks from various European countries with a focus on their design concept. Eye tracking Evaluation: to evaluate how students engage with double-page spreads of current German geography textbooks. This method captures students' reactions to different contents and designs in real-time. The combined findings from both of these analyses are then used to inform the development of a new textbook concept.
Mañas-Viniegra, L., Santos-Silva, D., Liberal-Ormaechea, S. [29] *Tripodos*	The visual-digital identity of corporate brands: A study of neuromarketing in young people from Spain and Portugal	With digital media's growth, brands modernized logos for clarity. Eye tracking and GSR revealed university students' preference for flat, simple logos over traditional ones.	Objective: Explore young university students' cognitive responses to traditional versus simplified flat brand logos. Understanding youth preference between traditional and contemporary flat logo designs. Techniques: • Eye tracking measured participants' attention towards various logos. • Galvanic Skin Response gauged emotional reactions.

Audi, M. *et al.,* [30] *International Journal on Disability and Human Development*	Analysis of the influence of the picture layout on the visual tracking of children and young people with cerebral palsy	The research examined the impact of screen placement on information selection in students with cerebral palsy. Results indicated optimal performance with images on the screen's upper and lower edges, with difficulties in the lower centre.	Objective: Study the impact of display characteristics on information selection accuracy and speed in students with cerebral palsy. Participants: 17 cerebral palsy students, aged 6-12. Data Collection: Eye tracking metrics processed using GraphPad V4. Analysis: Kruskal-Wallis test and Dunn's post-hoc analysis. Variables: Dependent - visual attention metrics; Independent - screen regions, display size, item count. Findings: Participants preferred upper/lower sides and struggled centrally, especially the lower centre.
Deeb, R. *et al.,* [31] *Color Research and Application*	Background and foreground interaction: Influence of complementary colours on the search task	The research examined how complementary colours on map labels affect readability versus traditional black labels, factoring in user traits. Eye tracking revealed significant correlations between colour variations, reaction time, and fixation duration.	Objective: Examine the readability impact of complementary colours vs. traditional black for map labels. Factors: Compared complementary colours to black labels; considered gender and expertise. Method: Eye tracking observed users during map tasks, measuring reaction time and fixation duration. Analysis: Assessed influence of colour hues and luminance on readability. Findings: Notable differences in eye metrics linked to colour contrasts, reaction times, and luminance-related fixation durations.

López, M. [32] *African Journal of Hospitality, Tourism and Leisure*	A comparative study of the perceived visual attractiveness level of hotel websites using the eye-tracking technique	Using eye tracking, the study compared website designs of booking.com and hoteles.com, finding millennials preferred Booking's straightforward layout and main image prominence. Additional insights came from a questionnaire.	Objective: Explore how website structure and visuals influence millennials' views on visual appeal. Focus: Analysed www.booking.com and www.hoteles.com Method: Eye tracking measured attention to website features; user feedback via questionnaire. Analysis: Cluster analysis examined design elements like main image type, text volume, and search function placement. Findings: Millennials favour single images, streamlined designs, and optimal search function positioning.
O'Neill, T., Wilkinson, K., Light, J. [33] *AAC: Augmentative and Alternative Communication*	Preliminary investigation of visual attention to complex AAC visual scene displays in individuals with and without developmental disabilities	The study evaluated gaze patterns on AAC displays, like VSDs, among groups including ASD and Down syndrome. Navigation bar placement influenced attention, emphasizing AAC design importance.	Participants: Individuals with ASD, Down syndrome, other disabilities, and typical pre-schoolers viewed simulated AAC displays. Key findings: Both VSDs and navigation bars garnered attention. Meaningful VSD elements attracted more focus than backgrounds. The navigation bar's position impacted attention on VSD elements. Implication: Navigation bar placement is crucial in AAC design and merits further research.
Otto, F. Rumpf, C. [34] *Sport, Business and Management: An International Journal*	Animation intensity of sponsorship signage: The impact on sport viewers' attention and viewer confusion	The study explored animation intensity in televised sports sponsorship signage using eye tracking on tennis clips. Increased animation enhanced viewer attention without confusion, highlighting its efficacy in sponsorship communication.	Setting: A laboratory experiment. Tool: Eye tracking methodology to analyse participants' visual attention towards animated sponsorship signage. Stimulus: Highlight video clips of a tennis match, incorporating five different intensity levels of animated sponsorship signage. Analysis: The study employed linear regression analysis and structural equation modelling to test the hypothesized causal relationships between animation intensity and viewers' attention and visual confusion.

Yoon, J., Syn, S. [35] *Library Hi Tech*	The effects of visual formats on Facebook health-related posts: evidence from eye movement analysis	Using eye tracking and surveys on participants viewing Facebook health posts, text-embedded images showed highest attention and recall. Graphics outperformed photos, emphasizing their role in health communication.	Design: Eye tracking experiment complemented by a survey. Participants: 42 individuals. Materials: 36 diverse Facebook health posts. Measurements: • Eye tracking assessed reading patterns and post engagement. • Surveys measured post recall and recognition. Analysis: Attention, recall, and recognition were compared across features like text-embedded visuals, pure visuals, graphics vs. photos, and text-image alignment.

4. Conclusions and Discussions

The utilisation of eye tracking technology in the field of visual communication design is having a significant impact on both academic and practical spheres. This systematic literature review (SLR) provides a comprehensive synthesis of existing research, elucidating the direction, methodology, and findings in this interdisciplinary field. Eye tracking is situated at the intersection of technology progress and core principles of design, providing unique and valuable insights into the dynamics of visual attention and their impact on effective design communication. The increasing incorporation of eye tracking technology in the field of visual design during the last decade can be seen as a responsive adaptation to the changing digital and visually immersive environment. Insights into the gaze patterns of viewers have become essential for designers and academics. This systematic literature review comprehensively explores the several functions of eye tracking, encompassing both conceptual design goals and observable viewer responses.

A diverse array of approaches has surfaced, encompassing meticulously controlled laboratory trials that examine the gaze on specific design elements, as well as more comprehensive field research that evaluates the usability of digital platforms. The aforementioned different approaches, despite their varying scopes, share a common objective of maximising the effectiveness of visual communication. Various factors must be taken into account, including the intricacies of typographic legibility [6], the arrangement of digital platforms [14], and the effectiveness of visual advertising. The fundamental aspect persists, which is the act of conveying information in a more concise and effective manner. These studies provide a template for professionals in the fields of web design [9], advertising [20,21], and user experience [19]. By incorporating various perspectives, the creation of visual storytelling is enhanced, resulting in the ability to attract audiences and successfully convey messages.

After evaluating a total of 34 studies, it becomes evident that there are multiple diverse uses and concerns associated with eye tracking technology. The influence of design components on several aspects such as attention, decision-making, and the overall user experience is readily apparent. The presence of this phenomenon is observable across various contexts, including the organisation of educational materials, the arrangement of digital platforms, and the composition of product packaging. It is worth noting that various demographic groups, particularly individuals with diseases such as autism or Down syndrome, demonstrate distinct visual responses, hence requiring the implementation of specialised design solutions. Moreover, although eye tracking provides significant data for the optimisation of advertising strategies, it also necessitates exercising caution. The utilisation of captivating designs may unintentionally lead to an overemphasis or misunderstandings, hence highlighting the necessity for a well-rounded approach in the development of designs.

In addition, the research that has been evaluated primarily focuses on sociological aspects [3,5,7-12,17-26]. There is a noticeable gap in thoroughly investigating the subtleties of visual attention, namely in the domains of cognitive [30-32,34], psychological [4,15,16,22,28,33,37], and cultural [7,27,29,31,35] factors. The process of visual perception is not solely determined by neurobiological systems but is intricately influenced by an individual's cultural background, social environment, and personal psychology. In certain cultural contexts where the reading direction is right-to-left, it is plausible that there may be variations in visual processing patterns compared to cultures where reading commences from the left. Likewise, it is plausible that socioeconomic circumstances could influence an individual's inclination to prioritise visual information, considering the diverse range of life experiences observed among various demographic cohorts.

In the realm of psychology, attention distribution can be strongly influenced by personal experiences, traumas, and individual preferences. For example, those who have experienced trauma associated with fire may exhibit heightened attention towards visual stimuli that bear even the faintest resemblance to flames, whereas individuals without such traumatic experiences may not readily notice such stimuli. Additionally, the advent of the digital era has brought forth a worldwide viewership for the majority of visual media. Therefore, it is imperative for designers and researchers to refrain from relying simply on a standardised comprehension of visual attention. It is imperative for individuals to take into account the wide array of human experiences and cultural backgrounds. The presence of diverse populations needs a more detailed and nuanced approach to conducting eye tracking studies, with a particular emphasis on the significance of cross-cultural research. The combination of these subtle distinctions presents a promising opportunity for further investigation, offering the potential for deeper understanding and a more comprehensive grasp of visual attention in our networked society.

In conclusion, this systematic literature review (SLR) on eye tracking within visual communication design comprehensively examines current expertise and progress while highlighting potential research trajectories. As technical innovation increasingly intertwines with design principles, the human eye's role in visual communication becomes paramount. Looking ahead, several promising directions emerge. Notably, the progression towards adaptive interfaces, which dynamically adjust displays based on gaze patterns, holds significance. This optimises data presentation to users. Virtual and augmented realities are burgeoning sectors warranting exploration, especially regarding visual attention within these immersive realms. Such insights can pave the way for more user-friendly experiences. The potential for tailored content dissemination is another intriguing avenue; platforms might soon adapt content based on individual visual attentiveness, aiming to bolster engagement and memory retention. The health sector, especially with younger demographics, stands to gain from a meticulous gaze pattern analysis which might aid early detection of conditions like autism. Professions demanding acute visual focus, such as air traffic control or surgical roles, could refine their training modules by assimilating eye tracking data. Furthermore, there is an opportunity to enhance digital inclusivity for disabled individuals by better understanding and catering to their visual attention patterns. For marketing and advertising, leveraging insights from visual attention studies could create more resonant content. Additionally, integrating immersive experiences, such as virtual and augmented reality, can significantly improve training and operational efficiency in these professions[36,37]. By combining eye tracking data with immersive technology, professionals can engage in more realistic and effective practice scenarios. In marketing, the fusion of visual attention insights with immersive experiences can create more engaging and memorable advertisements. Aesthetic experiences, when informed by eye tracking studies, can be tailored to captivate audiences more deeply, enhancing both user satisfaction and content effectiveness. The challenge ahead lies in delving deeper into these nuances, adeptly harnessing eye tracking, and crafting visuals that resonate with a diverse audience.

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