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Review Article

Biotechnology Section

Research Trends in Eye Gaze Tracking and its Implications: A Bibliometric Analysis

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ABSTRACT

Introduction: Eye gaze tracking is essential in understanding non verbal communication, human-computer interaction and cognitive responses. Its applications range from healthcare to consumer behaviour analysis and gaming. The evolution of eye gaze tracking technology and its increasing adoption highlight its significance across diverse domains.

Aim: To conduct a bibliometric analysis of eye gaze tracking research over the past two decades (2005-2024), exploring publication trends, collaboration patterns, key contributors and emerging research themes.

Materials and Methods: The present review was a bibliometric review in which data were extracted from the Web of Science Core Collection, amounting to 9,773 peer-reviewed articles. The bibliometric analysis tools used were VOSviewer and Biblioshiny for the investigation of co-authorship, citation and co-occurrence network analysis. The critical conceptual and intellectual trends in research on eye gaze tracking were identified, focusing on publication output and global collaborations in research.

Results: Findings showed that more than 62% of publications were published within the period 2018-2024. The United States of America (USA) accounted for the majority of research contributions, followed by England and Germany. Applications in healthcare, marketing and cognitive sciences were evident, with "autism" being a focus of critical importance.

Conclusion: Eye gaze tracking has seen rapid growth since 2018, with an increasing focus on Artificial Intelligence (AI)-assisted applications in healthcare, assistive technology and marketing. Emerging trends such as deep learning-based eye movement prediction and gaze-driven user experiences are shaping future developments. Upcoming research is expected to integrate AI, neuroscience and human-computer interaction to advance diagnostics and gaze-based security solutions.

Keywords: Eye movement analysis, Eye tracking system, Fixation, Gaze point, Human-computer interaction

INTRODUCTION

Non verbal communication in humans typically involves eye gazing, hand gestures, and facial expressions. The eyes are often referred to as the "windows to the soul," and eye cues help indicate emotions such as happiness, hatred, sadness, surprise and other feelings [1]. Mind mapping is feasible with eye gazing due to the similar utilisation of the temporal lobe by both [2]. Galvanic Skin Response (GSR) is heightened when paired with eye gazing [3]. The age of an individual, from a newborn infant to old age, has implications for eye gazing. Eye-gaze tracking has been adopted in multiple applications across various domains. Human-computer interaction without physical contact revolutionises the world by embracing technology and assisting even the disabled community. Eye-gaze tracking helps identify user engagement while using a particular service or application online.

Designers gain insights into the responsiveness associated with different widgets, enabling them to plan improvements and enhance revenues [4]. The marketing community can determine consumer behaviour concerning advertisements and product endorsements, as well as the reactions of like or dislike through the non verbal cues represented by eye gaze [5]. Neurological disorders associated with individuals can be studied through a patient-eye-gazing approach [6,7]. Extensive studies have utilised eye-gaze tracking techniques to assess conditions such as autism and schizophrenia [8-10]. Eye-gaze tracking can also assess a driver's alertness while driving [11]. Drowsiness or distraction while driving can be monitored, with instantaneous alerts raised when necessary [12].

The implications of eye gaze tracking across scientific research, technology development, education [13], marketing, healthcare, e-learning and various other fields are enormous. Technological advancements and their potential applications continue to expand, offering innovative ways to understand and interact with the world around us. Eye movements are tracked through multiple approaches in the literature. Electro-Oculography, Scleral Search, Infrared Oculography and Video Oculography [14] are the eye-tracking methods adopted across various disciplines. Video oculography has become increasingly popular with the rise of computing capabilities and available space. The gaze estimation of an eye can be made either through distinct features or its appearance [15].

A comprehensive bibliometric analysis of eye gaze tracking helps to identify the evolution of eye-tracking research over time, alongside technological advancements, research trends, key contributors and influential publications that can guide future studies. It maps interdisciplinary applications, funding sources and collaboration networks while highlighting knowledge gaps and emerging areas. The primary objective was to conduct a bibliometric analysis of eye gaze tracking research over the past two decades (2005-2024) to explore publication trends, collaboration patterns, key contributors and emerging research themes.

The secondary objectives included analysing the global distribution of research output to identify leading countries and regions contributing to the eye gaze tracking literature; recognising prominent authors, institutions and prestigious journals that are actively publishing in the domain of eye gaze tracking; identifying highly cited and impactful research documents to understand their contributions to the field; and highlighting research gaps, evolving applications of eye gaze tracking technology and emerging trends that pave the way for future investigations.

MATERIALS AND METHODS

This bibliometric analysis employed peer-reviewed documents indexed in the Web of Science (WoS) database (Clarivate Analytics) as the primary data source. WoS was selected due to its comprehensive coverage of high-quality academic literature across various scientific disciplines. The systematic search was conducted using the query string {(ALL=(Eye Gaze Tracking)) AND

(ALL=(Eye Gaze))}, ensuring the precise retrieval of documents related to eye gaze tracking research. The search process was performed on 12 January 2025, and it included all document types available in the WoS database. This study utilised secondary data obtained from publicly accessible bibliographic databases and did not involve human or animal participants. However, institutional approval was obtained from BLDE (Deemed to be University), Research and Development Cell, under Approval Number: BLDEU/RD/2024/EGT/62/1, dated 24 December 2024.

Data Cleaning and Processing

Following data retrieval, the collected records were exported in .csv format and imported into Microsoft Excel for initial screening and organisation. Duplicate records and non relevant documents were excluded through manual inspection. Discrepancies regarding document classification and relevance were resolved through consensus among the authors.

Analysis Tools

Bibliometric analysis was conducted using two specialised tools:

VOSviewer: This tool was used for generating co-authorship, keyword co-occurrence and citation networks. VOSviewer visualises bibliometric relationships by displaying network maps where the size of nodes represents the significance of an entity (e.g., author or keyword) and the thickness of links indicates the strength of relationships between entities.

Biblioshiny (a web interface for Bibliometrix in R): This tool was applied for descriptive bibliometric metrics such as annual publication trends, leading authors, the most productive countries, institutions and citation analysis. Biblioshiny provided a user-friendly platform for comprehensive analysis.

Visualisation and Mapping

Collaboration networks were visualised to identify the primary contributors and collaborations in the field of eye gaze tracking. Co-authorship networks were created to depict the strength of collaboration among researchers and institutions, while country-wise networks highlighted global research contributions. Keyword co-occurrence networks were generated to illustrate thematic clusters and emerging trends within the field.

RESULTS

Characteristics and Citations Analysis

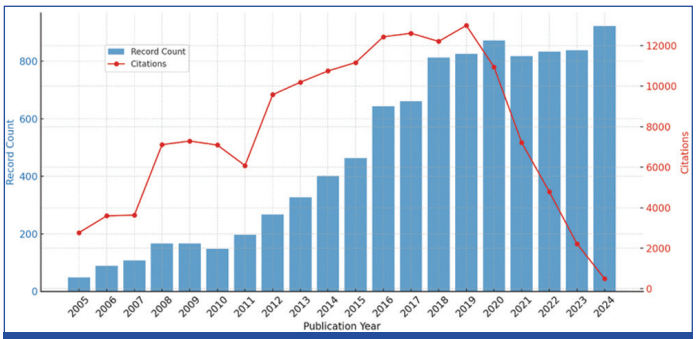
The bibliometric analysis presented in [Table/Fig-1] highlights 9,773 publications on eye gaze tracking from 2005 to 2024, sourced from 3,574 journals, books, and other platforms. Articles constitute the largest share of document types, with 6,105 (62.45%), followed by proceedings papers with 3,002 (30.71%), while reviews and other formats account for less than 10%. Author collaboration is notable, with an average of 4.5 co-authors per document, and 2,517 (25.74%) of publications involving international partnerships. Additionally, the analysis indicates a total of 155,918 citations and 210,890 references, with each document receiving an average of 15.96 citations.

Description	Findings
Time span	2005-2024
Sources (Journals, Books, etc.)	3,574
Number of documents	9,773
Document type	
Article	6,105 (62.45%)
Proceedings paper	3,002 (30.71%)
Review	229 (2.34%)
Early access	128 (1.31%)
Article; Proceedings paper	118 (1.21%)
Others (Letters, Early Access, Data Papers, Book Chapters, etc.)	191 (1.96%)
Authors	
Authors	26,116
Authors of single-authored documents	299
Authors collaboration	
Single-authored documents	336
Documents per author	0.37 (0.37±0.00)
Authors per document	2.67 (2.67±0.00)
Co-authors per document	4.5 (4.5±0.00)
Citations	
Average citations per document	15.96 (15.96±0.00)
Citations	1,55,918
References	2,10,890
Keywords	
Keywords plus (ID)	8,123
Author's keywords (DE)	17,109

[Table/Fig-1]: Characteristics and citations analysis on publications associated with Eye Gaze Tracking (2005-2024).

Annual Publication Trends

[Table/Fig-2] illustrates the year-wise distribution of publications and citations on eye gaze tracking from 2005 to 2024. A gradual increase in the number of publications is observed, with significant growth occurring between 2012 and 2020, reaching a peak in 2024 with 922 records. Citations exhibit a similar trend, peaking in 2019 with over 13,000 citations, followed by a decline in subsequent years. The consistent rise in publications and citations highlights the growing research interest and advancements in the field over the last two decades.



[Table/Fig-2]: Year-wise distribution of publications and citations on eye gaze tracking (2005-2024).

Prolific Authors

The top 10 authors listed in [Table/Fig-3] exhibit varying levels of research productivity and impact in eye gaze tracking, with Kasneci

Authors	Number of papers	Total citations	H-Index	Citations per item	Citations per item per year
Kasneci E	73*	1292*	21*	17.69	1.6
Bulling A	67†	1292*	21*	19.28	1.48
Gellersen H	46‡	1059	18‡	23.02‡	1.91
Park KR	43	820	16	19.06	0.95
Niehorster DC	36	785	14	21.8	2.72‡
Falck-ytter T	34	1265†	20†	37.2*	2.32
Duchowski AT	33	692	12	20.96	1.16
Hooge ITC	29	857	15	29.55†	2.95†
Darzi A	28	773	17	27.6	1.38
Hessels RS	27	868‡	17	32.14	4.01*

[Table/Fig-3]: Top-10 authors in terms of their productivity and various bibliometric indices.
*, †, and ‡ indicate first, second, and third rank in specific columns, respectively

E and Bulling A leading in the number of papers (73 and 67) and total citations (1,292 each). Hessels RS, had the highest citations per item per year (4.01), reflecting a strong and consistent research impact. Falck-ytter T demonstrates notable productivity, with the highest citations per item (37.2) among the top 10 authors. Overall, [Table/Fig-3] underscores diverse citation patterns and research influence, showcasing both prolific and high-impact authors.

Top Contributing Journals Related to Eye Gaze

As shown in [Table/Fig-4], Frontiers in Psychology ranks highest in productivity with 219 publications (NP), followed by PLoS One with 159 publications and the highest Total Citations (TC) of 3,717. Journal of Autism and Developmental Disorders had the highest Average Citation per Paper (ACP) at 33.98, indicating substantial research impact per article. Autism Research demonstrates the highest impact factor of 5.3, reflecting its significant influence in autism-related eye gaze research. Additionally, PLoS One exhibits strong citation performance with an h-index of 36, a g-index of 54, and an m-index of 2.118, indicating consistent and influential contributions over time.

Sources	NP	TC	ACP	h-index	g-index	m-index	Impact factor
Front Psychol	219*	3469†	15.84	31	47	1.938‡	2.6
PLoS One	159†	3717*	23.37	36*	54*	2.118†	2.9
J Eye Mov Res	158‡	1901	12.03	24	36	1.333	1.3
Sensors	124	1422	11.46	20	31	1.538	3.2
Sci Rep	106	1374	12.96	22	32	2.2*	3.8
Behav Res Methods	101	2906‡	28.77‡	28‡	51†	1.4	4.6†
IEEE Access	98	923	9.41	16	27	1.6	3.4
J Vis	92	2861	31.01†	29†	51†	1.526	2
J Autism Dev Disord	79	2685	33.98*	27	50‡	1.421	3.9‡
Autism Res	59	1202	20.37	19	34	1.056	5.3*

[Table/Fig-4]: Journals with eye gaze relevant publication.
NP: Number of publications; TC: Total citations; ACP: Average citation per paper
*, †, and ‡ are first, second, and third rank in specific columns, respectively

Most Relevant Affiliations

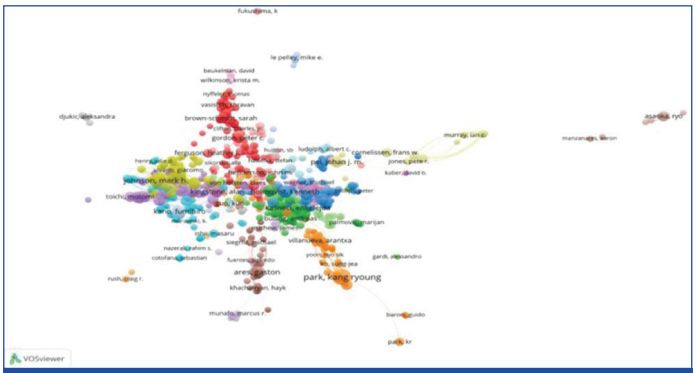
As shown in [Table/Fig-5], the University of London ranks highest in productivity with 248 publications (NP) and the highest total citations (7,740 TC), achieving an impressive h-index of 44. The Max Planck Society leads in research impact with the highest APP of (32.7) across 172 publications. The University of California System closely follows in both productivity and total citations, with 230 publications, 7,074 citations, and an h-index of 43, indicating consistent and high-impact research. Notably, University College London, Harvard University, and Eberhard Karls University of Tübingen maintain strong research output and influence, as reflected in their high APP, TC, and h-index values.

Affiliations	NP	APP	TC	h-index
University of London	248*	31.27†	7,740*	44*
University of California System	230†	30.76‡	7,074†	43†
Centre National De La Recherche Scientifique (CNRS)	174‡	15.7	2,731	27
Max Planck Society	172	32.7*	5,625‡	40‡
Eberhard Karls University of Tubingen	145	17.81	2,582	30
Swiss Federal Institutes of Technology Domain	141	15.14	2,135	25
University College London	135	27.15	3,665	35
State University System of Florida	116	17.66	2,048	24
Harvard University	114	24.39	2,780	28
Pennsylvania Commonwealth System of Higher Ed	112	14.27	1,598	22

[Table/Fig-5]: Top Institutions contributing to eye gaze-related works.
NP: Number of publications; TC: Total citations; APY: Average publication per year
*, †, and ‡ are first, second, and third rank in specific columns, respectively

Author Collaboration Analysis

The co-authorship network analysis of the eye-gaze tracking field, visualised in [Table/Fig-6] using VOSViewer software, highlights key researchers and their collaboration patterns. Each node in represents an author, with the node size reflecting the total number of publications and the colour coding indicating the average citation count per document. The links between nodes show collaborative relationships, with thicker links denoting stronger co-authorship connections. Researchers positioned outside the main clusters in [Table/Fig-6] may represent independent work or minimal collaboration with others. This analysis provides valuable insights into identifying influential researchers, fostering potential collaborations, and understanding the structure of scientific partnerships in the eye-gaze tracking domain, thereby supporting young researchers in building networks and advancing their expertise.



[Table/Fig-6]: Eye gaze research collaborators.

Most-cited Articles with Citation Count

As shown in [Table/Fig-7], Dalton KM et al., lead in total citations (1,078 TC) with a strong citation rate of 51.33 citations per year (TC/year), highlighting their significant influence in autism research. Hansen DW and Ji Q rank second with 900 citations and a high citation rate of 56.25 TC/year, reflecting a notable impact in gaze modelling studies. While Wang K et al., rank lower in total citations (490 TC), they achieve the highest citation rate of 70.00 TC/year, indicating rapidly growing relevance in Bayesian adversarial learning. Overall, the top articles in this table exhibit citation rates

Authors	Article title	Source title	Citation	TC per year
Dalton KM et al., [16]	Gaze fixation and the neural circuitry of face processing in autism	Nat Neurosci	1078*	51.33
Hansen DW and Ji Q [17]	In the eye of the beholder: A survey of models for eyes and gaze	IEEE Trans Pattern Anal Mach Intell	900†	56.25†
Harms MB et al., [19]	Facial emotion recognition in autism spectrum disorders: A review of behavioural and neuroimaging studies	Neuropsychol Rev	731‡	45.69
Armstrong T and Olatunji BO [18]	Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis	Clin Psychol Rev	722	51.57‡
Guastella AJ et al., [20]	Oxytocin increases gaze to the eye region of human faces	Biol Psychiatry	618	34.33
Orquin JL and Loose SM [21]	Attention and choice: A review on eye movements in decision making	Acta Psychol	603	46.38
Senju A and Johnson MH [22]	The eye contact effect: mechanisms and development	Trends Cogn Sci	591	34.76

Kassner M et al., [24]	Pupil: An open source platform for pervasive eye tracking and mobile gaze-based interaction	Proc. ACM Int Jt Conf	506	42.17
Wang K et al., [23]	Generalising eye tracking with bayesian adversarial learning	IEEE/CVF Conf	490	70.00*
Senju A Csibra G [25]	Gaze following in human infants depends on communicative signals	Curr Biol	466	25.89

[Table/Fig-7]: Eye gaze related most cited articles with citation score [16-25].
TC: Total citations
*, †, and ‡ are first, second, and third rank in specific columns, respectively

above 45 TC/year, emphasising their substantial and consistent contributions to eye-gaze research [16-25].

Most Scientific Production Countries

The USA ranks first across all metrics in [Table/Fig-8], with 2,529 publications (NP), an average of 126.45 publications per year (APY), the highest total citations (58,399 TC), and the highest h-index (102). England ranks second in productivity (1,472 NP) and citations (25,449 TC), sharing second place in h-index (68) with Germany, which ranks third in publications (1,018 NP) and citations (22,423 TC). China, despite being fourth in productivity (965 NP), has a relatively low total citations count of 8,280 and an h-index of 41, indicating a growing but less established research influence. Notably, Japan and Australia share third place in h-index (46) and maintain a competitive citation count, with 9,831 TC and 8,879 TC, respectively.

Countries	NP	APY	TC	h-index
USA	2529*	126.45*	58,399*	102*
England	1472†	73.6†	25,449†	68†
Germany	1018‡	50.9‡	22,423‡	68†
Peoples R China	965	48.25	8,280	41
Canada	644	32.2	6,031	39
Japan	535	26.75	9,831	46‡
Australia	424	21.2	8,879	46‡
Netherlands	393	19.65	7,874	43
France	372	18.6	6,070	38
Italy	357	17.85	6,023	38

[Table/Fig-8]: Global leaders in eye-gaze research: A country-wise analysis.
NP: Number of publications; TC: Total citations; APY: Average publication per year
*, †, and ‡ are first, second, and third rank in specific columns, respectively

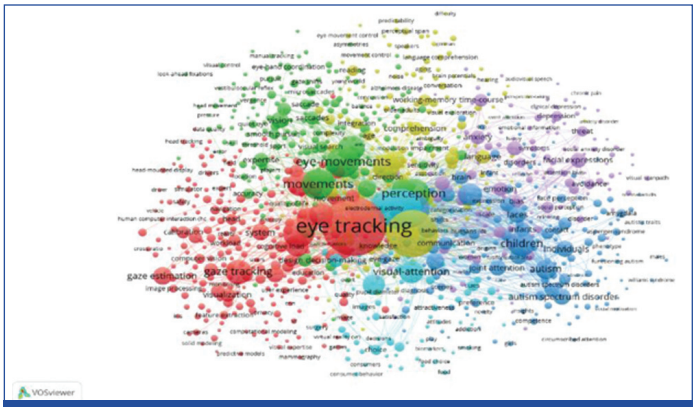
SCIENTIFIC MAPPING ANALYSIS

The analysis of keywords selected by authors in scientific articles helps researchers identify core topics within the study domain. This study analysis author keywords based on frequency, cluster associations, trending patterns, and thematic progression over a 12-year period to gain deeper insights into the evolution of research in eye-gaze tracking.

Co-occurrence Analysis

Co-occurrence analysis is performed to determine the frequency and patterns of keywords related to eye-gaze tracking, using data extracted from the WoS database. This method unveils the relationships and associations of terms related to eye-gaze and their application areas, describing how these concepts are interrelated and evolve over time. By identifying significant connections and recurring patterns, co-occurrence analysis is highly informative in providing insight into the current state of research and highlighting potential directions for future studies.

Keyword co-occurrence: In [Table/Fig-9,10], "eye tracking" dominates eye-gaze research, ranking first in total link strength (11,851) and occurrences (2,571), and appearing prominently at the centre of the network map. The second-ranked keyword, "eye-tracking" (9,483 link strength, 1,669 occurrences), further underscores the significance of this research area. In [Table/Fig-9], Cluster 1 (red) focuses on technical aspects such as gaze estimation and tracking systems, while Cluster 2 (green) emphasises eye movements, perception and fixation, consistent with high-ranking keywords in [Table/Fig-10]. Cluster 3 (blue) highlights research on autism and children, aligning with the top ACP keyword "autism" (34.96 ACP), indicating its high impact in developmental studies. Overall, the combined analysis illustrates that eye-gaze research encompasses technical, cognitive and clinical fields, with a strong citation impact in areas such as visual attention, autism and recognition.



[Table/Fig-9]: Co-occurrence visualisation network.

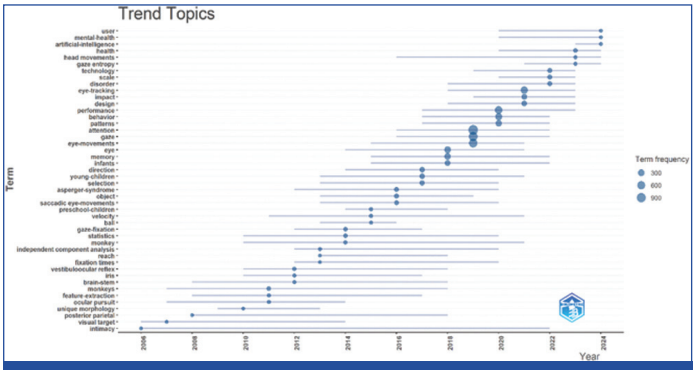
Keywords	Total link strength	Occurrences	Avg. citations	Cluster
Eye tracking	11851*	2571*	15.3839	1
Eye-tracking	9483†	1669†	14.3146	4
Attention	8918‡	1250‡	21.224	6
Gaze	6663	1014	20.3215	3
Perception	5081	673	20.7474	2
Eye-movements	4464	699	17.1717	2
Movements	3939	666	18.8168	2
Children	3869	459	27.3638‡	3
Information	3526	465	23.6667	4
Tracking	3396	630	17.0381	1
Performance	3105	439	16.0547	1
Eye movements	3043	463	26.0821	2
Visual-attention	2913	379	29.9842†	6
Recognition	2833	363	28.3939‡	3
Autism	2700	295	34.9627*	3
Model	2478	387	21.7054	1
Behaviour	2274	314	18.7834	6
Fixation	2163	289	27.1522	2
Visual attention	2154	315	18.6508	6
Memory	1882	246	23.7561	4

[Table/Fig-10]: Co-occurrence keywords related to eye gaze.

Eye Gaze Related Trend Topic Analysis

In [Table/Fig-11], the trend topics in eye-gaze research are presented over time, showing the increasing prominence of key terms between 2005 and 2024. Early research topics, such as "eye movements," "fixation," and "gaze," appeared prominently around 2010, reflecting foundational work in eye-tracking studies. From 2015 onward, more advanced topics such as "artificial intelligence," "mental health," and "technology" gained momentum, indicating the integration of eye-gaze research with emerging fields like AI and healthcare. Notably, terms like "health," "performance," and "attention" reached high frequencies by 2024, as represented by larger circles, highlighting their significant role in current research. Overall, [Table/Fig-11]

illustrates the evolution of eye-gaze research, with early technical topics transitioning to interdisciplinary applications in health, AI, and cognitive sciences.



[Table/Fig-11]: Keyword burst indicator based on author input.

DISCUSSION

The outcome of this bibliometric study reveals a substantial rise in eye-gaze tracking research over the past two decades, particularly after 2018, indicating its growing prominence across multiple domains. The analysis of 9,773 documents from the WoS Core Collection highlighted not only the increasing annual publication trends but also the key contributors, leading institutions, impactful journals and frequently studied themes such as autism, attention and perception. The United States emerged as the most productive country, followed by England and Germany, with the highest citation influence and collaborative links, aligning with previous bibliometric reviews by Brasil ARA et al., (2020) and Zammarchi G and Conversano C (2021) on eye movement biometrics and medical applications, respectively [26,27].

The study's keyword co-occurrence and trend analysis revealed that "eye tracking," "attention," and "autism" are among the most frequent and impactful terms, reflecting the domain's expansion into cognitive science, developmental psychology and healthcare. This observation aligns with findings by Aryadoust V and Ang BH, who discussed the surge in eye-tracking applications in language learning and mental health assessments [28]. Furthermore, the inclusion of newer keywords such as "artificial intelligence" and "mental health" in recent years implies an interdisciplinary fusion with advanced technologies, as reported by Singh J and Modi N and Salgado-Fernández A et al., [29,30].

Compared with similar studies, such as that by Salgado-Fernández A et al., who evaluated the influence of eye movements on academic performance, the current research expands further by mapping global collaboration networks and identifying dominant themes across clusters, thereby offering a macro-level insight into the evolution of the field. While earlier studies focused on narrow thematic or regional scopes, this study takes a more comprehensive global and cross-disciplinary perspective [30].

The implications of these findings suggest that eye-gaze tracking is not only a mature field of research but is also rapidly diversifying, with promising prospects in diagnostic tools, user experience evaluation, cognitive load assessment and adaptive learning systems. The insights generated can guide future research priorities, particularly in unexplored applications or underrepresented regions.

Limitation(s)

The outcomes of the eye-gaze-related study are confined to data from the WoS Core Collection database alone. Furthermore, the bibliometric analysis in this study is predicated on the abstracts, keywords and titles of publications rather than an exhaustive content analysis. Therefore, there is considerable opportunity to enhance the scope of this research by incorporating a core content analysis involving bibliographic data sourced from multiple indexed databases.

CONCLUSION(S)

Eye gaze tracking technology is an emerging field with increased potential for interdisciplinary work. The growth in the number of research publications after 2018 signifies a heightened focus on research studies related to AI-aided gaze tracking, healthcare, and human-computer interaction. There is a shift in research towards applied studies, particularly in cognitive neuroscience, assistive technology and marketing analytics. While revolutionary groundwork and research have developed immensely, new trends in AI-based case analysis, deep learning-based prediction of eye movement and gaze-driven user experience are driving forthcoming developments.

Further research may focus on AI-augmented gaze estimation, gaze-based security solutions and neurological applications. Future studies may combine artificial intelligence, neuroscience and human-computer interaction to rationalise diagnostic procedures in medicine.

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