Mapping the Landscape of Eye-Tracking Research: a Systematic Bibliometric and Thematic Analysis of Studies in ACM CHI and CHIIR Proceedings

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Eye-tracking technologies are integral in human-information interaction and information retrieval research, offering a robust method to study system performance and human physiological responses during interactions. This study presents a systematic bibliometric analysis and thematic analysis of eye-tracking studies published in the ACM CHI and CHIIR conference from 2014 – 2024, which represent the most rigorous and influential research globally. Among the identified 227 eligible studies, Key findings include: (1) The COVID-19 pandemic significantly affected the volume of eye-tracking research; (2) Researchers from 37 countries contributed to the included studies, but the overall researcher collaboration network is highly sparse and fragmented; (3) U.S. and European agencies were top funders; (4) The primary research topics in the ACM CHI conference included User Experience and Usability, Interaction Techniques and Devices, Virtual Reality and Augmented Reality, Collaboration and Communication, and Cognitive and Behavioral Aspects of human-computer interaction (HCI). Notably, eye-tracking studies in CHIIR conference proceedings were extensively used to analyze search behaviors, evaluate information retrieval systems, information visualization, and online collaboration. (4) Most eye-tracking studies focused on healthy and young undergraduate participants; (6) Tobii eye trackers have been the most commonly used devices; These findings illuminate the current state of eye-tracking research in ACM communities, identify research gaps, providing a roadmap for upcoming research and fostering collaboration for the ACM CHI and CHIIR eye-tracking community.

CCS CONCEPTS • General and reference~Document types~Surveys and overviews • Human-centered computing~Human computer interaction (HCI)

Additional Keywords and Phrases:, Eye Tracking, Bibliometrics, Thematic analysis

1 INTRODUCTION

Eye tracking is a technique for capturing and analyzing eye movement by using infrared light to detect the reflection of the cornea and pupil, followed by measuring their relative positions [1]. Eye-tracking technologies have been widely adopted in Human-Computer Interaction (HCI) and Human-Information Interaction (HII) research to assess cognitive workload [2], track visual attention distribution [3], and study how users engage with information systems. By analyzing where the participants' gaze lingers, researchers can identify areas where they feel confused or frustrated [4] and evaluate user interface (UI) design [5]. Eye tracking also enhances collaboration [6] and accessibility in technology design [7, 8] for users with physical disabilities by offering alternative control mechanisms through gaze-based interaction.

An eye-tracking device is essential for conducting eye-tracking studies. However, selecting the right devices can be daunting due to the variety of options available and the high price tags. Eye-tracking devices can be broadly categorized based on their setup in the testing environment. The two primary types are screen-based and head-mounted eye trackers [9]. Screen-based eye trackers are typically attached to or placed under the screen the user is viewing, providing a non-intrusive way to monitor eye movement. In contrast, head-mounted eye trackers require users to wear the device as glasses or a headset, providing more flexibility for studying gaze behaviors in real-world settings. With advancements in immersive reality and artificial intelligence (AI), virtual reality (VR) and augmented reality (AR), such as FOVE, HTC, and Meta Quest, have integrated eye tracking as an important feature [10-13]. Recently, researchers have been increasingly focused on making eye-tracking solutions more affordable and accessible through webcams [14, 15] mobile device [16, 17].

For researchers utilizing eye-tracking technology, a useful approach is to seek syntheses of empirical eye-tracking studies and connect with the research community. While several existing reviews have focused on specific applications of eye tracking, such as usability and user experience (UX) [18], emotional and cognitive process [19], education [20], tourism [21], information systems design [22], mobile devices [23], and child computer interaction [24]; these reviews are limited in scope and do not provide a comprehensive understanding of the overall productivity of eye-tracking studies, research communities, scientific influence in both HCI and HII. As early as 2008, Marchionini [25] observed a shift in HCI community towards focusing on interactions with information, rather than computers alone. This shift was formally recognized with the first ACM Conference on Human Information Interaction and Retrieval (CHIIR) conference in 2016, sponsored by the ACM Special Interest Group for Information Retrieval (SIGIR) in collaboration with ACM Special Interest Group on Computer-Human Interaction (SIGCHI). HCI is increasingly concerned with how people interact with information [26]. However, many existing reviews fail to capture this shift and offer limited insights concerning the broader landscape of eye-tracking research within this field.

To address this gap, we conduct a systematic bibliometric and thematic analysis to map the landscape of eye-tracking research, and the research communities presented in the ACM Computer-Human Interaction (CHI) and CHIIR proceedings. The CHI conference is widely recognized for publishing rigorous and influential research in the HCI field, including significant contributions to eye-tracking studies. Over the past decade, CHI papers have introduced enhancements in eye-tracking technology [2, 27-29] and featured studies that apply eye tracking in various contexts, from usability testing to integration with brain-computer interfaces (BCI) and VR [30-32]. Likewise, the CHIIR conference is well-known for its emphasis on HII, focusing on information seeking contexts, and user-centered approaches to information retrieval, access, and use [33]. Eye tracking has been widely adopted in CHIIR research to explore user interaction with information systems [34-36]. Furthermore, publications from CHIIR received an average of 3.05 citations per year, which is similar to the impact of CHI publication from 2016 to 2022 [37]. Thus, we selected these two conferences as representative sources of high-quality research to investigate the development and application of eye-tracking technology in the HCI and HII fields.

Bringing together CHI and CHIIR can offer valuable insights into ACM eye-tracking community. This connection allows the HCI community to apply theoretical HII frameworks to system design, while advanced eye-tracking technologies from HCI research can be shared with the HII community to improve the accuracy and efficiency of search behavior analysis. Therefore, this study aims to present the current state of eye-tracking research and researcher communities within the CHI and CHIIR conferences and identify significant studies, contributing authors, research collaboration patterns, research topics, application of eye tracking, and potential gaps. Specifically, we address the following research questions (RQs):

Bibliometrics

- RQ1: How has the volume and impact of eye-tracking research at the CHI and CHIIR conferences evolved over the past 10 years? Who funded the eye-tracking studies?

Researcher collaboration

- RQ2: What is the geographic distribution of contributing authors? Who are the top contributors, and what are their collaboration networks in CHI and CHIIR eye-tracking research?

Thematic insights

- RQ3: What topics are frequently addressed in CHI and CHIIR eye-tracking research, and what potential gaps can be identified for future research?
- RQ4: What are the characteristics of participants recruited in CHI and CHIIR eye-tracking studies?
- RQ5: What types of eye trackers or equivalent devices have researchers commonly used in CHI and CHIIR research, and what are the typical setups for these devices?
- RQ6: What are the roles of eye-tracking technologies in the CHI and CHIIR conferences?

2 METHOD

We used a systematic bibliometric analysis and thematic analysis approach to achieve the research aims. Bibliometrics is a quantitative research method that examines the characteristics of a group of publications. This quantified research synthesis is typically used to map the research landscape and identify research patterns, collaborations, influence, and impact [38-41]. This method has been widely used for science mapping across disciplines. Thematic analysis was used to identify and interpret themes within the qualitative data extracted from the included publications. This method provided insights into research topics, application of eye tracking, and research gaps.

2.1 Publication Search

To identify relevant publications, we developed an initial search query based on previously published reviews focusing on eye-tracking technology [18-23]. We then refined the search query through iterative testing, incorporating various terms and their variations pertinent to eye tracking. The final search strategy below was customized for use in both the Scopus database and the ACM Digital Library. The Scopus database offers comprehensive coverage of scholarly publications in multiple disciplines, including the ACM CHI and CHIIR proceedings. Using both Scopus and ACM Digital Library, we aim to ensure this study captures all relevant eye-tracking publications contributed by the ACM CHI and CHIIR communities. In addition, we focused on publications in the past decade to provide a clear picture of the evolving research landscape and ensure they are relevant to the present research context. Search results from two databases were aggregated, deduplicated, and then imported into Covidence [42], a web-based systematic review software, to facilitate study selection.

"eye fixation" OR "eye gaze" OR "eye motion" OR "eye movement" OR "eye movements" OR "eye track" OR "eye tracker" OR "eye tracking" OR "eye-fixation" OR "eyegaze" OR "eye-gaze" OR "eye-movement" OR "eye-movements" OR "eyes fixation" OR "eyes fixations" OR "eye-tracker" OR "eye-tracking technology" OR "eyetracking" OR "eye-tracking" OR "gaze movement" OR "gaze pattern" OR "gaze track" OR "gaze tracking" OR "gaze-tracking" OR "movement of the eye" OR "ocular movement" OR "pupillary dilation" OR "pupillary response" OR "visual fixation" OR gazetracking OR saccade OR "gaze detect"

2.2 Study selection

Two reviewers independently screened each retrieved article at the title-abstract level based on a set of inclusion and exclusion criteria. Inclusion criteria: (1) research publications at the CHI conference proceedings from January 2014 to December 2024 and at CHIIR conference proceedings from January 2016 (first issue) to December 2024; (2) original research articles involving an eye-tracking study; (3) studies with human participants; (4) studies involving eye-tracking technology; and (5) studies introduce new algorithms or metrics for eye-tracking data analysis. Exclusion criteria: (1) documents that are not original research articles, such as abstracts, posters, perspectives, editorials, or notes; (2) studies do not use eye-tracking devices; (3) studies do not focus on HCI; and (4) studies where the main population is non-human. The discrepancies between the two reviewers were discussed and resolved within the research team. The publication search and study selection are illustrated in Figure 1.

2.3 Data collection

Our data collection, extraction, and manual coding were guided by the best practices recommended in eye-tracking research [31][32] and our research questions. We developed three major data measures for our research questions: bibliometrics, research collaborations, and thematic insights. The data collection for the bibliometric and research collaborations measures was based on the bibliographic metadata collected from Dimensions [43] and Altmetric Explorer [44], which are start-of-art research databases and research tools developed by Digital Science. The Dimensions database indexes over 100 million publications and offers advanced bibliometric measures and analytics functions, while Altmetric is an online attention and engagement tracking system for research publications across various platforms, including social media, news outlets, and blogs. In the thematic analysis, we developed a codebook (Appendix A.1) to facilitate data extraction from the full texts of eligible publications. Each full-text article was reviewed and manually coded at least twice by the first author and collaboratively by two other authors. Following the initial coding and data extraction, conflicts were resolved collaboratively by the research team.

2.3.1Bibliometrics

Our bibliometrics measures focused on the distribution of publications by year, funding agencies, and research impact. The research impact in this study refers to citation impact and digital or social influence [41, 45] .Citation impact was measured by the Field Citation Ratio (FCR) [45] from Dimensions, and the digital and social impact was measured by the Altmetric Attention Scores (AASs) [44]. The FCR is an advanced citation metric that compares a publication's impact with similar articles in the same field and year, providing a more unbiased measure than raw citation counts that disadvantage publications from more recent years. Dimensions provides FCRs for its indexed publications at least 2 years old, with a benchmark of 1.0 indicating average impact. AASs provided by Altmetric [44], quantify digital attention from social media and online platforms, measuring scholarly influence beyond traditional citations [44]. An AAS score of 20 typically indicates above-average digital attention.

We collected the bibliometric data for relevant publications from the Dimensions database [43] by mapping the DOI and title of included publications. Dimensions'Artificial Intelligence (AI) embedded analytics features, provide instant analysis and visualization of research outputs, including publications, grants, and datasets. Using this state-of-art research tool, we exported full citation records and data on the distribution of publications by year, funding agencies, and AAS, through an institutional license to Dimensions and Altmetric Explorer.

2.3.2Research Collaborations

ACH CHI and CHIIR are vibrant and interdisciplinary research communities that attract scholars from all over the world. Understanding the structure of these communities is essential for external researchers who wish to engage with and contribute to ACM CHI and CHIIR. Therefore, we focused on key metrics highlighting the scope and strength of research collaborators and collaboration networks. We collected co-authorship data from Dimensions, including the geographic locations of all contributors, the top contributing authors, and the major research collaboration networks and characteristics. The researcher collaboration networks were generated through the Dimensions database web application, which incorporated VOSviewer [46] a state-of-art bibliometric network analysis software. The VOSview has been widely used to analyze and visualize co-authorship clusters [47, 48]. Notably, the Dimensions database addresses author name ambiguity through a combination of algorithmic and manual processes [49]. We also manually verified identified top contributing author names, their affiliations, and their associated number of publications in the dataset. In this study, we provided a comprehensive overview of the global reach and collaborative dynamics within the ACM eye-tracking research community.

2.3.3 Thematic insights

For the thematic analysis, we addressed the gap identified in the previous synthesis of eye-tracking studies within HCI and HII by disclosing major topics, the role of eye-tracking in CHI and CHIIR studies, the characteristics of study participants, and adopted eye-tracking equipment. These measures offer newcomers to the eye-tracking community with evidence-based knowledge, assisting them in better understanding the current research content and getting started with a solid foundation.

2.4 Data Analysis

Our data analysis and visualization were primarily based on the bibliographic data exported from Dimensions and Altmetric Explorer, as well as manually coded data exacted from the full text of each included publication. Visualizations were generated using the analytical features in Dimensions and VOSviewer. Table 1 outlines the measures, metrics, data sources, and analytics tools used, along with the corresponding research questions they address.

Table 1: Data measures, categories, metrics, source and analysis tools.

RQ	Measures	Categories	Metrics	Data Source	Analysis Tools
RQ1	Bibliometrics	Research productivity	Total number of publications in a calendar year	Dimensions Altmetric Explorer	Microsoft
		Funding agencies	Number of publications supported by each funder		

		Citation impact	FCR & AAS		
RQ2	Researcher collaboration	Author characteristics	Co-author geographic distribution Top contributing author & affiliation	Dimensions	Microsoft Excel, Dimensions Analytics, VOSviewer, Gephi
		Community	Collaboration networks characteristics (density, connected components, modularity, average clustering coefficient, centrality)		
RQ 3-6	Thematic insights	Topics	Total number of publications in each topic Topics of collaboration network cluster	Full-text & Manual coding	Microsoft Excel
		Role of eye tracking	Number of each role that eye tracking plays in CHI study		Microsoft Excel
		Participants	Participants group Range of age Vision criteria		Microsoft Excel
		Eye-tracking equipment	Brand, model, sample rate of eye tracker Setup of device		Microsoft Excel

Particularly, we examined the characteristics of researcher collaboration networks using the following four widely used descriptive measures: network density, connected components, modularity, average clustering coefficient, and eigenvector centrality. Definitions and interpretations of these measures are in Table 2. We imported the master dataset downloaded from Dimensions to VOSviewer to construct an All Co-authors network and then used Gephi [50] to generate the descriptive statistics for the measures. As free and open-source software, Gephi is widely used for network analysis and visualization due to its flexibility and robust features for exploring large and complex networks [50]. In addition, we used the Dimensions visual analytics view to visualize the collaboration network of the top 100 co-authors who contributed to 2 or more publications.

Table 2: Research Collaboration Network Characteristics

Network metrics	Definition	Measurement	Interpretation
Density	The percentage of actual links to all possible links in a network [51]	The level of connectivity between nodes within a network	A higher density suggests a more connected network, while a lower density indicates fewer connections.
Connected Component	A group of interconnected nodes in a network but not connected to other nodes outside the group [52]	The degree of cohesiveness or fragmentation in the network	Larger connected components suggest a cohesive research community, while multiple smaller components indicate fragmentation or specialization.
Modularity	The degree to which a network is divided into distinct modules or communities [53]	The community structure within the network	Modularity values range from -0.5 to 1. Higher values indicate strong community structures, with dense internal connections within the same community but sparse connections between different communities.

Average clustering coefficient	A measure to quantify the degree to which nodes in a network tend to cluster together [54]	The extent of clustering between nodes	A high coefficient suggests the formation of close-knit communities, while a coefficient of zero indicates no clustering. A coefficient of 1 means all co-authors in a network are fully interconnected.
Eigenvector Centrality	The quantity and quality of a node's connections, which are measured by the total number of connections a node has and if it is connected to other nodes that are also well connected [55]	The influence of a node in the network based on its connections	Nodes connected to other well-connected nodes have higher influence (higher eigenvector centrality), indicating great influence within the network.

3 RESULT

After the manual screening, we identified 227 relevant eye-tracking studies published at CHI and CHIIR proceedings (Figure 1) and included for data analysis. This dataset includes 191 studies from CHI conference and 36 from CHIIR conference proceedings. Results are organized based on each adopted measure.

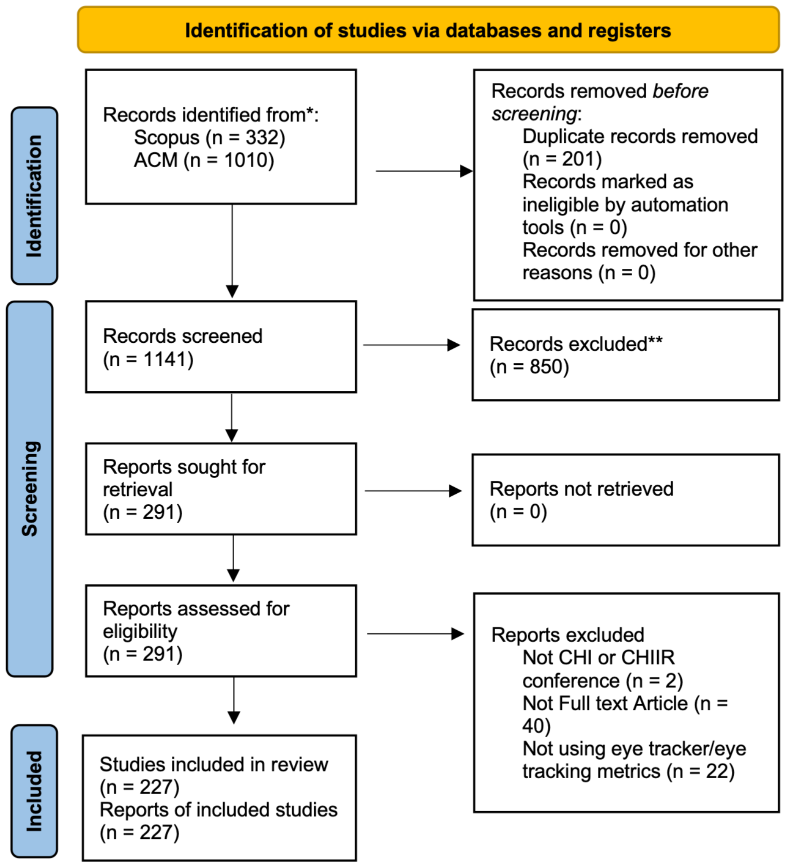

Figure 1: PRISMA diagram [56] of publication search and study selection

3.1 Bibliometrics

The number of eye-tracking publications at CHI and CHIIR was steadily growing since 2016, reaching a peak of 30 publications in 2020. This trend decreased to 15 publications in 2021 and further dropped to 11 publications in 2022, which is the lowest point of the decade. Following this decline, an increase occurred in subsequent years, with the number of eye-tracking publications rising to 25 in 2023 and 28 publications in 2024.

A total of 57 unique funding agencies from 20 different countries are acknowledged by the included publications. Among them, 41 are government agencies, 8 nonprofit organizations, 3 educational institutions, and 5 companies (i.e., Google, Oracle, Microsoft, Abbott, & Lockheed Martin). The National Science Foundation (NSF) in the United States supported 21 included studies, and Deutsche Forschungsgemeinschaft (DFG), a nonprofit organization in Germany, funded 18 studies. Other major funding agencies include the Engineering and Physical Sciences Research Council (EPSRC) from the United Kingdom (12 studies), and the European Research Council (ERC) and European Commission (EC), both based in Belgium, supported 10 and 9 studies, respectively. All funding agency countries are in high-income countries except China and India.

The research impact measure by FCR shows that, out of 227 publications, 174 have FCR scores, and 96% of them are above 1.0. The FCRs were not normally distributed and ranged from 0 to 66.56, with a median of 9 and an interquartile range of 12. Regarding the digital impact measured by AAS, 155 publications had AAS, and 11 publications' AAS values were above 20.

3.2 Researcher collaboration

Researchers from 37 countries contributed to the 227 eye-tracking publications, including those from the United States (n=73 publications), Germany (n=59) and the United Kingdom (n=46). Other top contributing countries included Australia (23 publications), Denmark (21 publications), Canada (19 publications), and China (16 publications). Researchers from European countries such as Finland, Switzerland, and France also show a strong presence, publishing 15, 9, and 8 publications, respectively. Authors from Japan published 13 studies.

A total of 789 distinct author names were identified from the master dataset, and 732 of them have verified author unique IDs in Dimensions. There are 128 authors who contributed two or more publications. Table 3 lists the top 10 researchers who contributed the most. All top contributing authors are from universities across the globe, including the United Kingdom, Denmark, Canada, Germany, Australia, and the United States.

Table 3: Top 10 Most Contributing Researchers (each coauthored >=5 publications)

Researcher Name	Current Organization	Publications
Hans-Werner Gellersen	Lancaster University (United Kingdom)	14
Ken Pfeuffer	Aarhus University (Denmark)	9
Ludwig Sidenmark	University of Toronto (Canada)	7
Jacek Gwizdka	The University of Texas at Austin	7
Antti Olavi Oulasvirta	Aalto University (Finland)	7
Florian Alt	Bundeswehr University Munich (Germany)	6
Tilman Dingler	University of Melbourne	5
Joshua Newn	Lancaster University (United Kingdom)	5
Mohamed Khamis	University of Glasgow (United Kingdom)	5
Andreas Bulling	University of Stuttgart (Germany)	5
Christof Lutteroth	University of Bath (United Kingdom)	5

As shown in Table 4, the overall collaboration network is highly sparse and fragmented, with a low density of 0.006 and 107 connected components, indicating that only 0.6% of all possible connections between nodes are present in the current network, and many groups are disconnected or have very limited collaboration across all researchers. The Top 100 Co-authors network shows fewer connected components (15) and a higher density of 0.037, suggesting that top contributing authors collaborated more extensively despite still being distinct groups. High modularity values (0.946 vs. 0.822) in both networks demonstrate strong community structure, indicating collaborations are more common within groups than between them. In addition, the average clustering coefficient in the All Co-authors network is higher than the Top 100 Co-author network, suggesting collaborations tend to be more local and researchers collaborate within tight-knit groups. Several influential authors were identified by their centrality values. Ken Pfeuffer (Denmark) and Hans-Werner Gellersen (United Kingdom) are not only the most contributing authors but also act as bridges between different groups and facilitate widespread collaboration (Figure 2).

Table 4: Research Collaboration Network Characteristics

Network metrics	All Co-authors Collaboration Network (N=789)	Top 100 Co-authors Collaboration Network	Interpretation
Density	0.006	0.037	The overall density of the research collaboration is highly sparse while top contributing authors are more interconnected and collaborate more frequently with each other.
Connected Component	107	15	The overall network is fragmented into many isolated groups; top contributing authors are more connected than others but still in several isolated clusters.
Modularity	0.946	0.822	All co-author collaboration network and top contributing author collaboration networks have high modularity, indicating a very strong community structure. Researchers tend to form tight-knit groups with intra-group collaborations, but sparse inter-group collaborations.
Average clustering coefficient	0.927	0.764	Both the all-co-author collaboration network and the top contributing author networks have high average clustering coefficients, indicating a high likelihood of authors clustering together.
Eigenvector Centrality	Pfeuffer, Ken (1.0), Gellersen, Hans-Werner (0.883399); Sidenmark, Ludwig (0.704025); Schneider, oliver (0.633609); Newn, Joshua (0.622907); Khamis, Mohamed (0.583614); Clarke, Christopher (0.566925)	Pfeuffer, Ken (1.0), Gellersen, Hans-Werner (0.724485); Lystbæk, Mathias N (0.609719); Alt, Florian (0.606353); Khamis, Mohamed (0.578522) Newn, Joshua (0.541083) Clarke, Christopher (0.512017)	Pfeuffer, Ken and Gellersen, Hans-Werner are the most central researchers, not only contributing the most, but also connecting researchers.

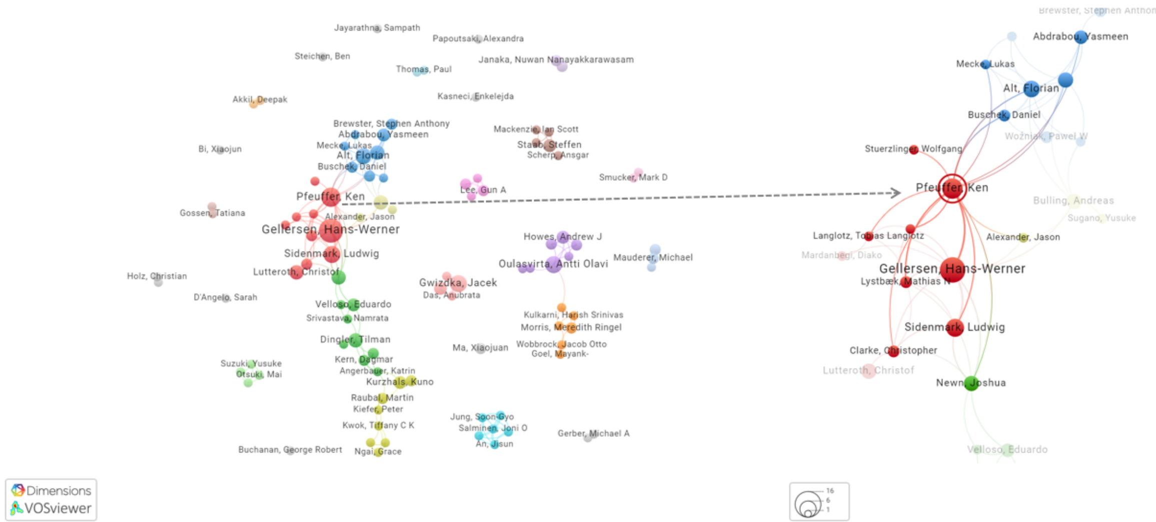

Figure 2 Top 100 Co-authors collaboration network generated in Dimensions via VOSviewer (each node represents a researcher contributing 2 or more publications; the color represents different research clusters; the size of the node corresponds to the number of publications included in this study; Left is the collaboration network of top 100 researchers whose number of publications>= 2; right is the collaboration of authors with the highest centrality (e.g., Ken Pfeuffer, Hans-Werner Gellersen)

3.3 Thematic insights

Among the 227 studies reviewed, 95% reported the total number of participants recruited. The number of participants ranged from 1 to 381 people. Due to issues such as inaccuracy, calibration failure, and data loss, it is common for eye-tracking studies to exclude certain participants' data from the data analysis. In this review, 39 studies reported excluding participant data, with the number of exclusions ranging from 1 to 93 cases.

102 studies provided detailed descriptions of their participant groups. The majority of eye-tracking studies recruited healthy, young adults, primarily undergraduate and graduate students, researchers and staff members. Four studies specifically focused on 6th to 9th grade children [57], children with autism spectrum disorder [58], deaf infants [59] and older adults [60]. Additionally, Five studies involved participants with disabilities to improve accessibility through eye-tracking technology [8, 61-65]. Studies also targeted participants from specialized occupations, including pilots, physicians, surgeons, professional players, and developers [66-70]. Studies aimed at understanding search behaviors often require participants to be either native [35, 71] or multilingual speakers [34, 72]. The age of participants ranged widely, from 8 months to 87 years old.

Vision status is a critical factor considered in eye-tracking studies. Among the reviewed studies, 38% of the studies reported visual criteria for participant recruitment. The majority of these studies required participants to have normal or corrected-to-normal vision. A few studies involving colored images in testing materials, excluded participants with color blindness [2, 73-77]. Moreso, studies focused on understanding how low vision people read specifically recruited participants with low vision or legally blind [65].

Table 5 presents the eye-tracking devices reported in the included publications, categorized by type, brand, and model, along with the number of publications associated with each model. Screen-based eye trackers were the most widely used type of eye-tracking devices. Screen-based eye trackers were preferred by CHIIR researchers, with 78% of all included

CHIIR studies reporting their use. In contrast, at the CHI conference, 50 % CHI papers reported the use of screen-based eye trackers in their studies. Among all screen-based eye trackers, Tobii was the most frequently mentioned brand. The Tobii EyeX was utilized in 12 publications, with a sample rate ranging from 30 Hz to 250 Hz. The SMI and EyeLink were also favored by many researchers, particularly the EyeLink 1000, which was reported to be used in 11 publications.

In the category of head-mounted devices, 1 CHIIR paper and 26 CHI papers utilized head-mounted devices in their study. The Tobii Pro Glasses 2 was the most cited eye tracker, appearing in 6 publications. With the growing interest in immersive technology, eye-tracking technology has been increasingly integrated into VR, XR and AR devices. 47 studies applied VR, XR or AR devices in their studies, one from CHIIR conference, the rest of them were from CHI conference. The HTC VIVE Pro Eye was the most commonly used VR device in eye-tracking study, mentioned in 12 CHI publications. Additionally, some researchers utilized mobile front cameras or action cameras to address accessibility issues associated with commercial eye trackers in certain situations. And in some cases, they developed their own custom eye-tracking devices for their studies [17] [78-80]

Table 5: Eye-tracking devices by type, brand and model

Type	Brand	Model (number of publications)
Screen-based	Tobii	Tobii EyeX (12), Tobii 4C (10), Tobii TX 300 (9), Tobii Pro X3-120 (8), Tobii X2-60 (7), Tobii T60 (3), Tobii T60 XL (3), Tobii 1750 (2), Tobii Pro Fusion (2), Tobii X 60 (2), 1750 Tobii eye-tracker (2), Tobii Dynavox I-13+ (1), Tobii eye tracker 5 (1), Tobii Pro Nano (1), Tobii Pro Spark (1), Tobii Pro X2-30 (1), Tobii REX (1), Tobii T120 (1), Tobii TX 60 (1), Tobii X 120 (1), Tobii X 50 (2), Tobii X3-120 (1), Unspecified (1)
	EyeLink	EyeLink 1000 (11), EyeLink 1000 Plus (3)
	SMI	SMI RED 250 (6), SMI REDn (4), SMI RED (3), SMI iView RED 250 (3), SMI iView X (1), SMI iView X RED (1), SMI RED 500 (1)
	The Eye Tribe	EyeTribe (6), Eye Tribe ET1000 (1)
	Gazepoint	Gazepoint GP3 (3)
	ISCAN	400 ISCAN eye-tracker (1)
	Logitech	Logitech C910 webcam (1)
	Pupil Core	Pupil Core 3 (1)
	Sony	Two Sony VFCB-EX480B infrared (IR) cameras (1)
	Unknow	Webcam (4)
Head-mounted	Tobii	Tobii Pro Glasses 2 (6), Tobii Glasses (1)
	SMI	SMI Eye Tracking Glasses (3), SMI (ETG1.8) (1), SMI Eye Tracking Glasses 2 (1), SMI model 2W (1)
	Pupil Core	Pupil Core glass (3), Pupil Core/Pupil Core Addon (1)
	Pupil Labs	Pupil Labs eye tracker (3)
	Self-developed	high-speed (120 Hz) on-axis near-eye infrared cameras (1), Home-made wearable monocular gaze tracker (1)
	EyeLink	EyeLink II (1)
	HoloLens	HoloLens with Pupil Labs' eye tracker (1)
	JINS Meme	JINS Meme (1)

	NAC Image Technology	EMR-9 eye-tracking recorder (1)
	PertechR	PertechR eye tracker (1)
VR &XR	HTC	HTC VIVE Pro Eye (12), HTC Vive with an integrated Tobii eye tracker (5), HTC Vive Pro Eye with an integrated Tobii eye tracker (2), HTC Vive (2), HTC Vive with an additional eye tracker (Pupil Labs) (1), HTC Vive Pro with an integrated Tobii eye tracker (1)
	HoloLens	HoloLens 2 (4), HoloLens2 (1), Hololens 2" (1), HoloLens 2 with customized MRTK's built-in gaze modules (1), HoloLens (1)
	Quest	Quest2 VR headset with a Tobii eye tracker (1), Oculus Quest (1), Meta Quest Pro headset (1), Meta Quest Pro (1)
	FOVE	FOVE (3), FOVE HMD (1)
	Pico Neo	PicoNeo 2 HMD with Tobii eye tracker (1), Pico Neo 3 Pro Eye (1), Pico Neo 2 Eye (1)
	Oculus	Oculus Rift DK2 headset that incorporated an SMI eye-tracker (1)
	Tobii	HP Reverb G2 Omnicept Edition VR headset with an integrated Tobii eye-tracker (1)
	Varjo	Varjo XR-3 (1)
	HP	HP Reverb G2 Omnicept (1)
	Unknow	Unknow (1)
Others	Android phone	Android Smart phone with OpenFace (1),
	Gazepoint	GazeSpeak with smartphone camera (1),
	GoPro	GoPro Hero3 camera (1),
	iPhone	iPhone 6 (2), iPhone X (2), iPhone XR with ARFaceAnchor API (1)
	Self-developed	Mobile Front-facing camera with Focus and Saccade Tracking (FAST) (1)

The analysis of publication topics reveals that the most popular topics that CHI researchers focused on were "User Experience (UX) and Usability," accounting for 44 publications. This was followed by "VR and AR" with 28 publications, indicating a strong interest in immersive technologies. Furthermore, major topics with more than 10 publications are Interaction Techniques and Devices, Cognitive and Behavioral Aspects, Accessibility and Inclusive Design and Collaboration and Communication. Under the field of Human Information Interaction, CHIIR researchers primarily concentrated on "Information Seeking and Use Behavior Analysis" (21 publications), "Information Visualization" (6 publications), "Search Interfaces" (5 publications), and "Collaboration and Communication" (1 publication). Additionally, two studies utilized eye movement data to improve model performance in predicting query terms and result relevance.

Over the past decade, eye tracking has been well-known for its ability to assess user experience and system usability. In this review, we found that 114 publications utilized eye tracking in this manner (Table 6). With increasing interest in leveraging eye movements as a method of interaction, 82 publications integrated eye tracking as input devices in their system design. Additionally, 18 publications focused on refining and enhancing eye-tracking metrics and algorithms, and 7 publications explored the design and development of new eye-tracking equipment.

Table 6: Role of eye tracking by number of publications

Role of eye tracking	Number of publications
Research or Usability evaluation tool	114
Input device	82

Innovation, development to eye-tracking metrics	18
Eye tracker replacement/ New eye tracker design and development	7
Others	4
Eye-tracking data quality	2

4 DISCUSSION

In this paper, we studied the bibliometrics of ACM CHI and CHIIR eye-tracking researchers by analyzing the number of publications, the regional distribution of research contributions, research impact using FCR and AAS. We also examined collaboration patterns through co-author network analysis and explored the diversity of research topics, participant populations, and the use of eye trackers in these studies, highlighting key trends and gaps over the past decade.

4.1 Bibliometrics

Our bibliometric results reveal a noticeable decline of eye-tracking studies in 2021 and 2022, with the number of publications dropping to 15 and 11, respectively, the lowest points in the decade. This decline is likely due to the global disruptions caused by the COVID-19 pandemic, as eye-tracking studies heavily rely on physical testing environments. Many researchers were forced to work remotely with lab closures, which made it difficult to conduct in-person experiments. Unsurprisingly, by 2023 and 2024, a recovery phase appeared, with an increase in eye-tracking publications, possibly indicating researchers catching up on delayed projects by resuming in-person studies.

Although there is widespread interest in using eye tracking for CHI and CHIIR research, eye trackers are expensive. Most studies are funded by well-resourced government agencies from Western countries. Our analysis revealed limited contributions from funding agencies or authors from low—and middle-income regions, particularly in South America, Africa, and parts of Asia. This disparity in research resources hinders the growth and inclusivity of ACM eye-tracking research community in these areas.

Nevertheless, the research impact analysis around FCR highlighted the high citation impact of eye-tracking research at CHI and CHIIR compared to similar works published elsewhere, confirming the strong influence of research published in ACM proceedings. However, the digital influence lagged behind, with only 11 publications achieving AAS scores above 20. This suggests that while the ACM CHI and CHIIR publications are impactful within academic communities, their visibility and engagement on social media and scholarly communication across social media and other digital platforms were limited. To maximize their research, researchers should leverage social channels to broadcast their research findings broadly, benefiting the public.

4.2 Researcher collaboration

Although 789 unique researchers were identified as contributors to the included studies, they have very limited collaboration across the entire group of eye-tracking ACM community. Most researchers have collaborated with only a few others. However, top contributing authors are much more connected with each other despite still working in isolated groups. Although the overall tendency of research collaboration is high, with an average clustering coefficient of 0.927 for all Co-author's networks, the collaborations were only observed within a limited number of groups, not widespread between groups, indicating a significant number of solo groups within the ACM CHI and CHIIR eye-tracking community.

Furthermore, there is a lack of international collaborations among researchers. Most collaboration clusters are concentrated in well-resourced regions such as North America and Europe. Other regions are rarely observed either contributing or collaborating with others. This signals a potential problem in this field because research collaborations often result in the sharing of knowledge, resources, and perspectives, all of which can drive creativity and innovation. The

ACM eye-tracking community should encourage more researchers to join and collaborate with each other so that the quality and impact of eye-tracking research can be further enhanced. Based on our results, we would like to promote collaborations between disconnected groups, reduce fragmentation in the network, and foster a more integrated research community. The identified influential researchers could be key in bridging the gaps and contributing to interdisciplinary collaborations. Most importantly, the ACM eye-tracking community needs to provide opportunities for less-connected researchers, emerging groups, and newcomers to support their integration into the broader network.

4.3 Thematic insights

CHI and CHIIR community have greatly benefited from utilizing eye tracking, offering valuable insights into user behavior analysis, system design and privacy and security. Jacek Gwizdka and his team studied the impact of eHealth literacy on online health search behaviors [81] and the effects of interactive AI design on user behavior in fact-checking systems [71]. Meanwhile, Florian Alt, Daniel Buschek, and their team applied eye-tracking technologies to analyze head, eye, and hand movements for user identification, authentication, and accuracy assessment [82]. In 2022, they extended their work to predict password reuse based on gaze behavior and keystroke dynamics [83].

Eye-tracking technologies has also become increasingly popular as input devices in immersive environments. Hans Gellersen and Ken Pfeuffer, who stand out as central node in the collaboration network has employed eye-tracking technologies for gaze selection [84-86] and eye-head interaction [85] in various fields such as VR, AR [86, 87]. Similarly, Gun A. Lee and his team have focused on investigating accurate gaze selection in immersive environments [88-90]. Xiaojun Bi and his collaborators introduced the Gaze typing system, GlanceWriter, and monitored participants' gaze behavior during typing tasks [91].

Another emerging topic is the integration of eye-tracking technology into remote collaboration, explored by various research groups within both communities. For example, Sarah D'Angelo designed a novel shared gaze awareness visualization [92] and evaluated different gaze visualizations for collaborative work [93]. Similarly, at CHI 2017, Mai Otsuki and Yusuke Suzuki introduced ThirdEye, a technology that supports gaze cues in video communication systems [94]. At CHIIR 2019, Alexandra Papoutsaki presented "Eye-Write," a system that enables co-authors to share their gaze location during collaboration [95].

Despite continuous refinements in eye-tracking metrics and algorithms [27, 96], existing eye-tracking studies still face limitations related to cost, operational complexity, and setup requirements. Researchers in the CHI and CHIIR community have begun developing eye-tracking alternatives using readily available resources, such as webcams and mobile phone cameras [97, 98]. This trend is driven not only by the need to overcome logistical challenges brought by pandemic but also by the potential to make eye tracking more cost-effective and widely applicable across various contexts in the future.

Our study observed a few researchers bridging the CHI and CHIIR communities. In 2019, Dagmar Kern, Tilman Dingler, and their collaborators presented their observations on users' reading behaviors with automatically highlighted abstracts at CHIIR [99]. Later, at CHI 2023, Tilman Dingler and his team introduced a novel, scalable implicit method for measuring deep versus skim reading behaviors on mobile platforms [100]. Tatiana Gossen and her collaborators describes the design and initial results of an eye-tracking study with both primary school-aged children and adults at CHI 2014 conference [101]. She further investigated user search behaviors from a psychological and a neurobiological perspective for predicting user intentions and published her study at CHIIR 2017 proceeding [77].

This review has found that many researchers prefer recruiting young, healthy university students as study participants. Only a few studies include people with disabilities or children in their participant groups. This trend has also been noted in another review focusing on eye-tracking research [18]. While recruiting young and healthy students can help avoid data distortion and yield highly reliable data, it limits the generalizability of the findings to a broader user population. In addition, the limitation of commercial eye trackers also causes older adults to be underrepresented in eye-tracking studies. A strong aging effect on saccadic reaction times has been reported, with younger adults showing significantly faster mean reaction times in both the overlap and gap conditions compared to older adults [102]. Understanding age-related differences in website navigation is crucial for design, especially with the increasing number of older adults using the Internet [103]. Future research should consider to recruit a more representative participant pool. This could involve collaborating across disciplines and investing in eye-tracking device and algorithms to make it more applicable to all age groups. Addressing this gap is essential for extending the application of eye tracking to design information systems that serve diverse populations [104].

As the first bibliometric study to systematically examine studies involving eye tracking published in the ACM CHI and CHIIR conference proceedings in the most recent decade, we identified a growing interest in applying eye-tracking technologies within these communities and observed the exceptional high citation impact of these studies. However, we also identified several gaps, including limited digital attention, minimal research collaborations among most researchers, the disparity in research funding and collaborations between well-resourced countries and low-and-middle-income regions, and the overrepresentation of health and young adults as study participants. To strengthen the ACM eye-tracking research community, it is essential to promote accessibility and inclusivity in research practices, foster cross-disciplinary and international collaborations, and diversify the study population. We believe these efforts will enable the CHI community to grow even more vibrant and impactful, creating opportunities for new and established researchers to come together for innovations.

5 LIMITATIONS

This study has several limitations. First, notes and poster abstracts were excluded due to their limited information, but they may still contain relevant insights. Second, while we initially aimed to extract data related to eye-tracking measurement and metrics, this was excluded due to insufficient and inconsistent reporting in most studies, particularly those that integrated eye tracker as an input feature. Lastly, this review is limited to the CHI and CHIIR conferences, limiting its representation of the entirety of available literature in this field. While these conferences are widely recognized and cover a large portion of eye-tracking applications in HCI and HII, future research should aim to include a broader range of databases to provide a more comprehensive overview of eye-tracking technologies especially their clinical applications.

6 CONCLUSION

This study analyzed the use of eye-tracking technologies in research published in ACM CHI and CHIIR conference proceedings through bibliometric and thematic analysis. Our findings provide a comprehensive overview of the research landscape and community, including the distribution of publications, authors, research collaborations, eye-tracking devices, participant demographics, and key research topics. These offer valuable insights for researchers in the ACM eye-tracking community. Our analysis also revealed several gaps, including limited digital attention, restricted research collaboration, disparities in funding, and a lack of diversity in study participants. We encourage the ACM eye-tracking community to work collaboratively to make this field more accessible, inclusive, and integrated, fostering great opportunities and broader impact for all.

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A APPENDICES

A.1 Codebook

Code	Explanations
Research topics	
User Experience (UX) and Usability	Methods and techniques for evaluating user experience. Case studies on usability testing. Innovations in UX design.
Interaction Techniques and Devices	Development of new interaction devices, novel interaction techniques (e.g., multi-touch, gesture-based interaction)."
Accessibility and Inclusive Design	Designing Assistive technologies and accessibility solutions for diverse user populations, especially people with disabilities
Cognitive and Behavioral Aspects of HCI	Understanding user behavior and cognitive load in interactive systems.
Health and Well-being	Digital health and well-being technologies. HCI in healthcare settings.
Artificial Intelligence and Machine Learning in HCI	Develop AI and ML in interactive systems.
Games and play	Game design and evaluation.
Privacy and Security	User-centered approaches to privacy and security. Studies on user perceptions of privacy and security.
Virtual Reality (VR) and Augmented Reality (AR)	Design and evaluation of VR and AR systems.
Collaboration and Communication	Tools and techniques for enhancing collaboration.
Auto Driving	Developing, evaluating auto-driving system.
Education and Learning Technologies	Tools and methods for enhancing education through technology. Studies on technology in educational settings."
Information Seeking and Use Behavior Analysis	Investigating how individuals search, access, and utilize information, focusing on user behaviors, and factors influencing information retrieval systems.
Information Visualization	Turning complex data into visual representations
Search Interfaces	Developing and evaluating user-friendly search interfaces that facilitate efficient information retrieval
Roles of eye tracking	
Research or Usability evaluation tool	Serve usability evaluation tool that measures where and how long users focus their gaze on an interface.
Input-devices	Serve as Input device to enable an individual actually to interact with an interface by eye movement.
Innovation, development to eye tracking metrics	Develop eye-tracking metrics, Algorithms

Eye tracker replacement/ New eye tracker design and development	Didn't use commercial eye tracker, but developing new eye tracker replacement (webcam) or New eye tracker
Eye-tracking data quality	Discuss the validity and reliability of the recorded data such as precision and accuracy