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Exploration of Eye-Tracking Methodologies in Usability Testing of Digital Health Technology: A Rapid Review

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Abstract. Eye-tracking is deemed a promising methodology for usability evaluation studies in healthcare, however clear theoretical guidance and practice remains lacking. A rapid review was performed on current use of eye tracking as a usability evaluation method on digital health technologies in the period of 2019 to 2024. Usability evaluation studies were included when they described a digital health technology intervention in which eye-tracking technologies were applied. To gain insight into how eye-tracking technologies contributed to measuring digital health technologies' usability, data was extracted on the use of eye-tracking for usability and key study findings. Seventeen papers were included in the review. Findings show that eye-tracking is frequently combined with other usability evaluation methods, with high methodological diversity, to test the usability of DHT. Future research is needed to enhance understanding of the effectiveness of eye-tracking outcomes in DHT usability testing when combined with other usability evaluation methods in order to provide (usability) researchers theoretical guidance on its application.

Keywords. Eye-tracking, User-centred design, Digital health technology

1. Introduction

In the rapidly evolving landscape of (digital) healthcare, the integration of digital health technologies (DHTs) has marked a new era of information access, communication, and care [1]. This necessitates guaranteeing that DHTs are not only technologically advanced but also usable by meeting the diverse needs and goals of healthcare professionals, patients, and caregivers. Implementation of usable DHTs aids in supporting optimal care processes and health outcomes [2]. Various usability evaluation methods (UEMs) can be employed for measuring DHT's usability. The 'think aloud' (TA) technique and validated questionnaires (e.g., system usability scale) are examples of such UEMs to assess DHT effectiveness, efficiency and user satisfaction [3,4]. Technologies evolve, and so do UEMs. New methods emerge to further help measure or strengthen usability

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outcomes. Such a method is eye-tracking and can serve as a methodology where quantitative gaze data can be collected on the user's interaction with a DHT. Despite the promising potential of eye-tracking in DHT development and testing, widespread adoption is yet to be seen [5]. A systematic review published in 2015 on eye-tracking usability studies for health information technologies showed that eye-tracking is little and ineffectively used, and that clear theoretical guidance and practice was needed to enhance its application and interpretation [6]. Therefore, the aim of this study is to review how, in recent years, eye-tracking has been utilised in usability testing of digital health technologies in terms of insights gained, UEM method approach applied and experienced challenges to its application.

2. Methods

This rapid review (through PubMed, IEEE, ACM, and Scopus) was performed in February 2024. A dataset of the included studies can be found via: https://doi.org/10.6084/m9.figshare.25431946.v1. Three search topics were used: eye-tracking, usability evaluation and digital health technology. Papers were eligible for inclusion if the study was published in the last 5 years and reported on one or more DHTs where eye-tracking was utilised as a methodological tool to evaluate the DHT's usability. Articles were excluded if: (a) the focus of the usability evaluation was not on a DHT intervention, (b) eye-tracking technologies were not used for evaluating DHT usability or (c) usability metrics were not mentioned. For each eligible article we extracted: the type of DHT tested, in which software design life cycle phase (SDLC) eye-tracking was applied, the range of number of included study participants, and key findings of the usability study gained through applying eye-tracking technology.

Table 1. Overview of Medical Subject Headings and keywords used per topic (eye-tracking, usability evaluation, digital health technology)

Eye-tracking	Usability	Digital Health Technology
Eye-Tracking Technology [MeSH]	User-Centered Design [MeSH]	Medical Informatics [MeSH]
Eye OR Eye track* OR Eye-track*	Usability Evaluation OR	Digital Health OR Health App OR Health Information Technology OR Health Information System OR Health Application OR Health Information eHealth OR Electronic Health mHealth OR Mobile Health OR Medicine

3. Results

3.1. General characteristics and findings of included studies

In total, 349 articles were extracted from the databases, 84 of which were duplicates and deleted. Out of the remaining 265 articles, 17 (6%) met the inclusion criteria. On average 3 articles were published annually. Most articles were published in 2020 (29%) and in 2024 (January - February) already two articles were published on this topic. All studied DHTs were either in the Testing (41%) or Maintenance (59%) phase. The number of participants ranged from 5 to 93. The findings of the papers, with regard to using eye-tracking (ET) as a UEM, can be found in Table 2 below.

Table 2. Overview of tested DHT, design phases, number of participants, and key findings of included papers. ET= Eye-tracking, TA= Think Aloud, RTA= Retrospective Think Aloud, CTA= Concurrent Think Aloud

DHT	SDLC Phase(s)	# Participants	Key Findings
Electronic Health Record (EHR)	5. Testing (1x) 7. Maintenance (4x)	8-93	Gender-based differences in EHR navigation; highlight necessity for gender-sensitive usability testing [Seifer et al., 2021] Pupillometry and efficiency through eye-tracking assessed EHR fatigue; physiological measures may surpass self-reported perceptions [Khairat et al., 2020; Khairat et al., 2022] Redesign information display organisation mitigated effect of high data density; UEMs in general should focus more on user satisfaction and cognitive load [Al Chalayini et al., 2020] Importance of screen design, deduced through ET for clinical contexts and future (re-)designs [Kang et al., 2022]
Personalised Digital Care Pathway (PDCP)	5. Testing	24	User preference for compact vertical layouts; influence of information load, layout and structure on two different devices [Heijsters et al., 2023]
Manual defibrillator	7. Maintenance	31	ET outcomes matched self-reported usability; to preserve ET outcomes CTA was omitted [Schumann et al., 2023]
mHealth	5. Testing (2x) 7. Maintenance (2x)	14-20	Relevance of information hierarchy and layout in mHealth design [McCall et al., 2021] ET as a mean to replace the cognitive burden of TA for people with dementia [Boyd et al., 2021] ET+RTA to gage layout of information, understanding and usability, combined with RTA [Winter et al., 2021] ET+RTA identified crucial and in-depth usability problems; study design assessed to improve mHealth usability testing [Cho et al., 2019]
Computerised Provider Order Entry (CPOE)	7. Maintenance	10	ET as a feasible method to evaluate UI features and their impact on patient safety [Aufegger et al., 2020]
Anaesthesia Workstation (ANWS)	5. Testing	5	Users' gaze to observe user intuition; ET and TA combination to understand user actions [Ohligs et al., 2019]
Patient Portal	5. Testing	92	Video-based interfaces led to less efficient but more effective information seeking; need for balance between efficiency and effectiveness in patient portal design [Yin and Neyens, 2024]
Internet and mobile-based intervention (IMI)	7. Maintenance	10	Duration of reading time differed among users; highlighted improvement of usability and persuasiveness of tool [Idrees et al., 2023]
Left Ventricular Assist Device (LVAD)	7. Maintenance	32	ET to quantitatively and objectively measure patient training performance [Weiss, et al., 2021]
Peritoneal Dialysis (PD) device	5. Testing	16	Mobile ET provides insight into information processing and tasks performance related to UI features [Wegner et al., 2020]

3.2. Eye-tracking methodology for usability evaluation

In scanning the articles on reflections about the use of eye-tracking as a usability method, the researchers were generally positive towards its application. The application of eye-tracking was often combined with other UEMs (65%), to provide additional qualitative and quantitative data on the DHT's usability and the users' experiences. Five papers (35%) exclusively used eye-tracking to measure usability metrics. Other supplemental UEMs were: SUS (6 papers), TA, RTA or CTA (5 papers), post-test interview (5 papers), questionnaire (2 papers), QUIS (2 papers), Cognitive walkthrough (1 paper), Health-ITUES (1 paper), and PSSUQ (1 paper). Study designs combining eye-tracking with supplemental UEMs were different across the included studies. Eye-tracking provided researchers with quantitative and visual insights into where and how users directed their attention during interaction with digital interfaces. A number of articles additionally used eye-tracking data as a method to assess physiological metrics, such as: fatigue [7,8], cognitive load [9], and dementia diagnostic assessment [10]. Challenges and limitations posed by researchers on using eye-tracking as a methodology were about the extensive time required, insufficient technical and analysis skills, difficulties to fit with other UEMs, and eye-tracking data interpretation bias. Additionally, (indirect) user tasks interfered with the eye-tracking measurements, e.g., concurrent think-aloud and looking at the usability expert rather than the interface. Other UEMs, such as retrospective think-aloud protocols, interviews, surveys, were needed to glean deeper insights into user intentions and reactions.

4. Discussion

The purpose of this study was to rapidly review how eye-tracking has been utilised for usability testing DHTs. Our findings indicate that there is a consistent interest over time in deploying eye-tracking to evaluate usability of DHT. Overall, its application was either in a DHT testing or maintenance phase and often (65%) combined with other UEMs with dissimilar study designs and outcomes. Eye-tracking was most often used to provide insight into the users' gaze patterns and fixations and to assess and (re-)design information layout, hierarchy and screen interfaces. The eye-tracking methodologies have also been used to assess physiological outcomes; such as fatigue, cognitive load, and dementia. The utilisation of eye-tracking to gather physiological outcomes has been established in prior neurological/physical research or adapted upon in the included articles [7–10]. All applications of eye-tracking in this review were used to assess usability metrics, either exclusively through eye-tracking or in combination with other UEMs. These methodological combination approaches are indicative of the complementary nature of eye-tracking but also showcase a gap in best practices for applying such a methodology in a study design. User gaze patterns and attention allocation offers rich data, but we lack comprehensive knowledge on the capacity to fully elucidate user intentions, decision-making processes, and satisfaction levels. The results of this study reiterate that eye-tracking with other UEMs such as retrospective interviews and think-aloud protocols enriches the data pool, providing a more holistic view of the DHTs usability and user interaction [6].

This rapid review's two strengths were the use of different databases to investigate recent literature and the focus on the applicability of eye-tracking as a UEM for DHT. Even though the nature of this review was rapid, the results show a list of findings that

can help guide researchers to consider eye-tracking as a methodology in future UEM study designs and protocols. However, the amount of research found per DHT was sparse, making the external validity of the findings limited. Lastly, the key findings showcase that there continues to be a lack of uniformity in the studies' designs. Future research is needed to enhance our understanding of the effectiveness of eye-tracking in DHT usability testing when combined with different UEMs [11].

5. Conclusions

In recent years eye-tracking methodologies for DHT usability testing have been used to assess a variety of outcomes, often in combination with other UEMs. There remains a lack of uniformity in the study designs, which indicate that a more standardised evidence-based approach is still needed to ensure effective application of eye-tracking for usability testing. Future studies should aid turning eye-tracking into a usable UEM for DHT development and implementation, thus ensuring that these tools are designed and evaluated in a manner that meet the needs and expectations of end-users.

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