A SYSTEMATIC REVIEW ON THE METHODOLOGY OF EYE TRACKING - UNDERSTANDING THE SAMPLING DESIGN

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Abstract - Recognizing the expanding applications of eye-tracking technology across various fields, the paper examines its effectiveness through a comprehensive review of existing studies. This paper aims to assist researchers in harnessing the vast capabilities of eye-tracking technologies and employing the right size of the sample. Systematically reviewing extant research in the different domains with respect to the fundamentals and practices of eye-tracking methodology, this paper presents a concise, empirical eye-tracking demonstration.

The paper explores eye-tracking applications in domains such as communication science, programming and code comprehension, tourism research, consumer behavior in food choices, marketing research and online consumer behavior, industrial applications, social media marketing and online customer behavior, media consumption and human-computer interaction. The revealed data are based on the relevant studies of eye tracking usability. Additionally, we highlight the main problems and challenges, identify existing research gaps, and suggest directions for future studies. These contributions suggest future outlooks for how to incorporate optimal samples within eye-tracking methodology.

Keywords - Eye Tracking, Sample, Eye Tracking Methodology

I. INTRODUCTION

Selection of a sample population is generally performed with the intention of generalizing results to a broader population. In eye-tracking research, a sample refers to the group of participants or data points used to study eye movements, visual attention, or related behaviors. Defining a sample depends on the research objectives, methodology, and the specific questions being addressed.

We have analyzed the main aspects of defining a sample in eye-tracking research.

Despite the availability of accurate and usable eye trackers, there is still little information available on how to develop these system and what is appropriate sample to implement.

Eye tracking according to Santos, Oliveira, Rocha and Giraldi (2015), is a tool for analyzing visual attention and tries to link visual attention with rational and emotional responses of consumers. Eye-tracking measures the place where the person looks (gaze or fixation point), the time this person looked at a certain point, the movement of his eyes in relation to the head, the dilation of the pupil and the number of blinks (Santos et al., 2015). According to Nilsen and Pernis (2009), fixation investigates the phenomena of the eye being fixed on a given object, enjoying the details of the object, while, sequences refers to the rapid movement of the eye between two fixations (Iloka and Anukwe, 2020). The structure of the eye limits vision, with high acuity to a small part of the field of vision, called the fovea (center of visual sight, foveal vision). As a result, there is a strong motivation to move the eyes so that the fovea is directed towards whatever stimulus we are thinking about or processing at the given moment (Carter and Luke, 2020). As the name implies, eye tracking serves to study the movement of people's eyes and analyze their behavior based on this movement. That is, eye tracking tools are those that allow brands to see through the eyes of their potential buyers, not only within lab-based scenarios, but also during their actual purchase in real life (cited in Iloka and Anukwe, 2020).

Eye tracking has its roots in the work of Charles Bell in 1823, who was the first to link eye movement control to the brain, categorize different types of eye movements, and explain how they influence visual orientation (Carter and Luke, 2020). While eye tracking is typically viewed as a modern technology, its beginnings can be traced to the 19th century. Eye-tracking studies have their origins in the 1870s when Javal first discovered two primary types of eye movements involved in reading: fixations and saccades (Płużyczka, 2018).

Eye tracking is grounded in the eye/mind hypothesis proposed by Just and Carpenter (1976), which suggests that the point of fixation reveals the area of interest when viewing a visual display and completing a task (Andrychowicz-Trojanowska, 2018). The mid-1970s marks the beginning of the third and most important era of eye movement research, lasting until today (as Rayner, 1998, has distinguished three eras;

Andrychowicz-Trojanowska, 2018). Thus, this marked the establishment of the theoretical foundations of eye-tracking.

The rapid development of eye-tracking technology, combined with enhanced computer operations and data processing capabilities, drove significant growth in its use. The commercial use of eye-tracking was once complex, time-consuming, and expensive. This situation has changed in recent years due to new generations of infrared eye-trackers, which enable eye movement recording of participants under natural exposure conditions, with large amounts of stimuli, and at high precision and low cost (Wedel and Pieters, 2008).

The advancement of more sophisticated and adaptable eye-tracking methods has allowed an increasing number of researchers to engage in eye-tracking studies and broadened the scope of eye-tracking applications across various scientific fields and industries. As a result, the use of eye tracking in research has exploded over the past 20 years across several disciplines (Iloka and Anukwe, 2020; Carter and Luke, 2020). This finding is supported by our research on Web of Science, where we used the search term TOPIC: ("eye tracking" OR "eye-tracking" OR "eyetracking"). The results clearly show a gradual increase in the number of publications from 1963 to 2023, reflecting the growing interest and development in eye-tracking research over time.

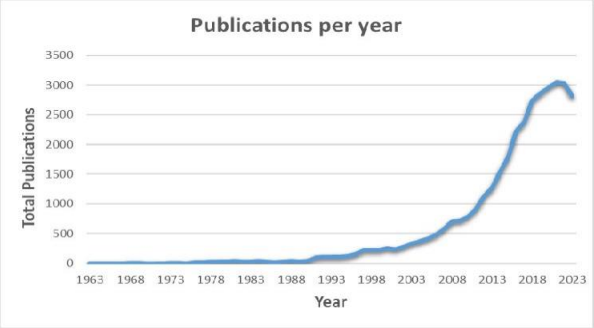

Figure 1. Total number of publications per year from 1963 to 2023 using the search term TOPIC: ("eye tracking" OR "eye-tracking" OR "eyetracking") in Web of Science.
(Source: Author's calculation)

Our aim is to present a detailed review of the diverse applications of eye-tracking research across different fields and the key insights it has generated thus far. We start by offering a brief background on eye-tracking methodologies, followed by an analysis of studies conducted in different countries and various fields. This review addresses common challenges and problems associated with the use of this method and provides recommendations for future research directions.

However, there are various eye-tracking studies conducted across different industries, showcasing the broad applicability of this methodology. Research in tourism (Wang and Sparks, 2016) focuses on image characteristics and ethnicity, while the food industry has explored consumer preferences for organic labels (Meyerding and Merz, 2018) and the impact of menu label design on food choices (Reale and Flint, 2016). In retail, studies compared mobile and stationary eye-tracking for package design (Pentus et al., 2019). Additionally, eye-tracking has been applied in fields such as information technology (Thilderkvist and Dobslaw, 2024), communication sciences (King et al., 2019), engineering (Schramm et al., 2019) and services (Wetzels et al.2024). Notably, marketing and media industries are frequently studied, with works focusing on influencer marketing (Boerman and Müller, 2022) and consumer engagement with online reviews (Maslowska et al., 2019). These studies illustrate the broad applicability of eye-tracking in analyzing consumer behavior, visual attention, and decision-making across diverse sectors.

The studies we are reviewing span a diverse range of countries, illustrating the global application of eye-tracking research. These include countries such as Australia, Germany, Great Britain, Estonia, Italy, the United States, the Netherlands, Sweden, South Africa, and Norway. This international scope highlights the widespread interest and relevance of eye-tracking across various fields, showcasing its utility in different cultural and industrial contexts.

II. OVERVIEW OF THE CURRENT RESEARCH - ANALYSIS OF THE PROBLEMS AND CHALLENGES OF USING EYE-TRACKING METHODOLOGY

The following section identifies some problems, limitations and considerations for future studies on the use of eye tracking in various fields, based on the results obtained from selected research papers.

Although, this methodology is widely used in many areas of research, there are still certain limitations, which can be overcome, with a careful approach in the application. An important limitation of eye-tracking methodology is that there is still little knowledge about how cognitive processes can be inferred from eye movements (Wedel and Pieters, 2008, cited in Kok and Jarodzka, 2017). The observed set of eye movements reflects the combined effects of many ongoing (cognitive) processes (Kok and Jarodzka, 2017). Iloka et al., (2020), consider that eye tracking tools cannot tell the user why someone is looking at a given point. The system can tell researchers what the

person is looking at, but not necessarily how the viewer perceives the point being looked at. As a second remark that the same authors add, it is related to the meaning of the fixations. Because a longer fixation may be an indication of interest or relevance to the target. At the same time, it can be an indication of uncertainty or difficulty in processing information and vice versa (Iloka et al., 2020). Theeuwes (1993) believes that eye movement, in itself, should not be considered as equating to a selection process, but "as a result of attentional selection processes that precede the actual eye movements" (Bucher and Schumacher, 2006). Moreover, the eye tracker can track overt eye movements, but it cannot track the covert movement of visual attention that occurs without eye movement. Eye-tracking data quality is often characterized by quantifying accuracy, precision, and data loss (explained in more detail by Hessels and Hoogea, 2019). According to Gredebäck et al. (2009), one of the potential disadvantages is also related to the financial aspect. That is, such equipment can be significantly more expensive, compared to traditional research methods (cited in Hessels and Hoogea, 2019).

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