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The Effect of Head-Up Display on Game Player's Eye Movements: Systematic Literature Review

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ABSTRACT

Head-up display (HUD) is a part of the game interface that is important as a medium of information for players. HUD generally takes the form of numerical, textual, or symbolic indicators in games. Interaction between game players and the HUD produces measurable differences in eye-movement behaviour, operationalized here as fixation count, fixation duration, and saccade velocity/amplitude. While several systematic literature reviews (SLRs) have examined eye tracking in games, none has isolated the HUD as the primary explanatory variable or reconciled the conflicting expert-novice findings that recur across this literature. This article addresses that gap by mapping research trends on HUD-driven eye movement and by synthesizing the recurring methodological practices used to collect eye-tracking data in this domain, to inform, rather than certify, future protocol design. Guided by the PRISMA approach, records were drawn from Google Scholar, Scopus, and ScienceDirect; ten studies published between 2015 and 2025 met the inclusion criteria and were analyzed through qualitative narrative synthesis (no meta-analysis was performed, given cross-study heterogeneity in eye trackers, tasks, and outcome metrics). The synthesis shows that fixation- and saccade-based outcomes diverge between expert and novice players in direction as well as magnitude, and that this divergence tracks genre-specific task demands (e.g., FPS/RTS versus MOBA versus racing) rather than a single uniform pattern. These findings are offered as an evidence base for eye-tracking protocol design in game-HUD research, not as a validated standard.

I. INTRODUCTION

The gaming industry has rapidly developed in society. Moreover, the gaming industry has now become a dominant force in the entertainment sector, significantly impacting social [1]. Starting from online games, offline games, and multiplayer games, they have all grown together [2]. This allows games to be filled with various types of content, such as educational or purely entertainment content [3]. The growth of the game is inseparable from technological advancements, the internet, and the adoption of smart mobile devices by the public. Making player interactions with the game change individually or collectively [4]. As a result, game developers and designers face a serious challenge in creating game products that can be beneficial for their players [5].

As the complexity of the game increases, there is a challenge in presenting important information from the game without disturbing the players. Here, the role of the user interface becomes crucial in building the virtual environment in the game [6]. Conventionally, the user interface in games consists of objects (avatars, enemies, targets) that interact with players in the main scene and background (interior or landscape) [7] and determine the visual appeal of the game [8]. In addition, the game user interface includes a head-up display (HUD) as an important component that mediates the player's interaction with information in the game [9]. Essentially, a good HUD prioritizes the display of relevant information, minimizes clutter, and can better group less important elements [10].

The HUD in a game appears as a graphical information display that can be placed at the top, bottom, or attached to the main character. For example, graphical information about a mini map, health status, game score, and much more [7]. The variations in HUD design come in various forms, such as non-diegetic HUD design, which means displaying all core information in the game beyond the game world itself, whereas diegetic HUD design means removing all graphic information elements from the game [11]. The use of HUD design, in addition to in games, is also available in flight simulations to assist pilots in processing information during flight tasks [12]. Then, the HUD is also used in car driving simulations as a digital guide aimed at enhancing driver attention and facilitating cognitive resources [13].

Systematic literature review (SLR) has been conducted by Anna Montolio-Vila, Marc Argilés, Bernat Sunyer-Grau, Lluïsa Quevedo dan Graham Erickson [14] focusing on the influence of action games (AVG) on eye movement. The results obtained show a positive impact of playing games, those of the AVG genre, on metrics that facilitate players' visual attention [14]. However, in the context of eye movements such as fixation, saccade, and pursuit, no conclusions were drawn during the gaming process or task execution [14]. The SLR conducted by Anna Montolio-Vila and her team [14] is still considered macro in evaluating based on the genre aspect, namely AVG, which affects visual attention and does not provide conclusions emphasizing the eye movement behavior of gamers. Three features distinguish the present review from that prior SLR and from the wider body of eye-tracking-in-games literature. First, the unit of analysis is narrowed from game genre as a whole to the HUD as a discrete interface component, allowing eye-movement outcomes to be attributed to a specific design element rather than to genre in aggregate. Second, this review explicitly reconciles the directionally conflicting expert-novice findings reported by individual primary studies (e.g., [7], [15], [16], [17]) rather than treating them as isolated results, and examines whether the direction of the effect covaries with genre-specific task demands. Third, this review couples the trend synthesis with a descriptive account of the data-collection procedures used across studies (eye-tracking hardware, trial duration, task structure), intended as an evidence base rather than a certified protocol, which the AVG-focused SLR by [14] did not attempt. This is because the HUD serves as a critical mediator that bridges the game system with the player's tactical decisions.

Research related to eye movement tracking in gamers affected by a HUD has become an interesting topic. This condition is inseparable from the development of eye trackers in generating eye movement data. The data produced includes eye movement metrics that can be analyzed to determine the number of fixations, fixation duration, saccade amplitude, and so on [15]. The research conducted by Loïc Caroux and Katherine Isbister [7] focused on understanding HUD choices that affect the gaming experience and providing recommendations for optimizing player interaction with the game. The results obtained show that the average fixation duration of novice players interacting with the HUD in the first-person shooter (FPS) and real-time strategy (RTS) game genres is higher than that of expert players. Another study conducted by John M. Joyce, Mark J. Campbell, Fazilat Hojaji, and Adam J. Toth [16] focused on the differences in visual attention of racing simulation players using the game object Assetto Corsa Competizione v1.8.18. The results showed that novice players had a higher fixation ratio on the racetrack than on the HUD than experienced players. Different research results were conducted by Cataneda and team [18] that showed no significant difference between expert players and novice players in interacting with the HUD (such as the mini map). In other conditions, expert players tend to focus more on the hero's health status area than other areas.

Previous studies on HUD-related eye movement report directionally opposite findings under superficially similar conditions: novice players show higher fixation counts than experts in some studies [7], [16], while others report the reverse [18], and a third pattern shows no expert-novice difference at all [18], [17]. The conceptual gap this review addresses is that no prior work has examined whether this divergence is attributable to (a) genre-specific cognitive demands on visual search, (b) differences in stimulus method and task structure (e.g., passive video-watching versus active play), or (c) sample-size and measurement-duration limitations that reduce statistical power, nor has any prior work systematically cross-tabulated these three candidate explanations against the reported outcome direction. Without this cross-tabulation, claims that HUD-related eye-movement outcomes simply "vary by genre" remain a description rather than an explanation. This review therefore synthesizes the ten included studies specifically to test which of these three candidate explanations best accounts for the observed inconsistencies.

To address the issues that arise, an SLR must be conducted. Fundamentally, the focus of this SLR is to identify research gaps and synthesize previous studies. Then, explore all potential eye movements of game players influenced by HUD based on empirical evidence.

In this review, the term "HUD influence" refers to measurable changes in players' visual behaviour resulting from the presence, spatial arrangement, information density, or semantic importance of Head-Up Display elements during gameplay. The influence of HUD is operationalized through objective eye-tracking metrics, including fixation count, fixation duration, total fixation duration, first fixation, dwell time, saccade velocity, saccade amplitude, saccade length, and gaze transitions between predefined Areas of Interest (AOIs). Within this review, fixation is defined as a relatively stable gaze maintained on a specific visual target for information processing, whereas saccade refers to rapid eye movements that shift visual attention between different fixation locations. Although operational definitions vary slightly among previous studies due to differences in eye-tracking algorithms and hardware, these metrics consistently represent visual attention allocation and information acquisition during gameplay.

In extracting data for the SLR to be more optimal, the research questions are as follows; First, what are the trends in previous research on the eye movements of game players influenced by the HUD? Second, what are the standard protocols for conducting effective research on eye movement data collection? To focus more on the core issue, this SLR aims to understand the development of research on the eye movements of game players influenced by HUDs, such as fixation and saccades. The selection of fixation and saccades serves as the basis for predicting eye movement patterns and the quality of the gaming experience when interacting with the interface or HUD [19].

The main contribution of this article is twofold. First, it presents a genre-differentiated classification of gamers' gaze behaviour by skill level, distinguishing patterns that recur within a genre from those that are genre-specific, rather than reporting a single "varies by genre" conclusion. Second, it produces a descriptive synthesis of the eye-tracking data-collection practices reported across the included studies (hardware, sampling rate, trial duration, task design); this synthesis is intended as a reference point for researchers designing future protocols, not as a validated or empirically tested standard, since no primary study in this review compared protocols experimentally. This review follows a qualitative narrative synthesis approach; because the included studies differ in eye-tracking hardware, task design, and outcome metrics, a quantitative meta-analysis was not performed, and no pooled effect size is reported.

II. METHOD

In this article, the SLR method uses the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. The guidelines for conducting an SLR using PRISMA include several steps starting from identification, screening, eligibility, and inclusion [20].

Articles used in the systematic literature review were retrieved from Google Scholar, ScienceDirect, and Scopus using the boolean search strings shown in Table 1, which combine synonym clusters for "video game", "HUD", "eye tracking", and "visual attention". The publication window (2015–2025) was applied as a screening filter after retrieval rather than as a database-level date restriction at query time, consistent with the identification counts reported below and in Figure 1; this is stated explicitly here for transparency. The search strings, databases, and publication window together define the search strategy for this review, detailed as follows:

TABLE I
SEARCH STRING

Data Base	Search String
Google Schoolar	Anywhere in the article ("video game" OR game) AND ("head up display" OR hud) AND ("eye tracking" OR "eye tracker") AND ("gaze behavior" OR "eye movement") AND (“visual focus” OR "visual attention") AND (“user experience” OR “player experience”) AND (“game interface” OR “user interface”)
ScienceDirect	All field ("video game" OR game) AND ("head up display" OR hud) AND ("eye tracking" OR "eye tracker") AND ("gaze behavior" OR "eye movement") ("visual focus" OR "visual attention")
Scopus	("video game" OR game") AND ("head-up display" OR hud) AND ("eye tracking" OR "eye tracker") AND ("gaze behavior" OR "eye movement") (“visual focus” OR "visual attention")

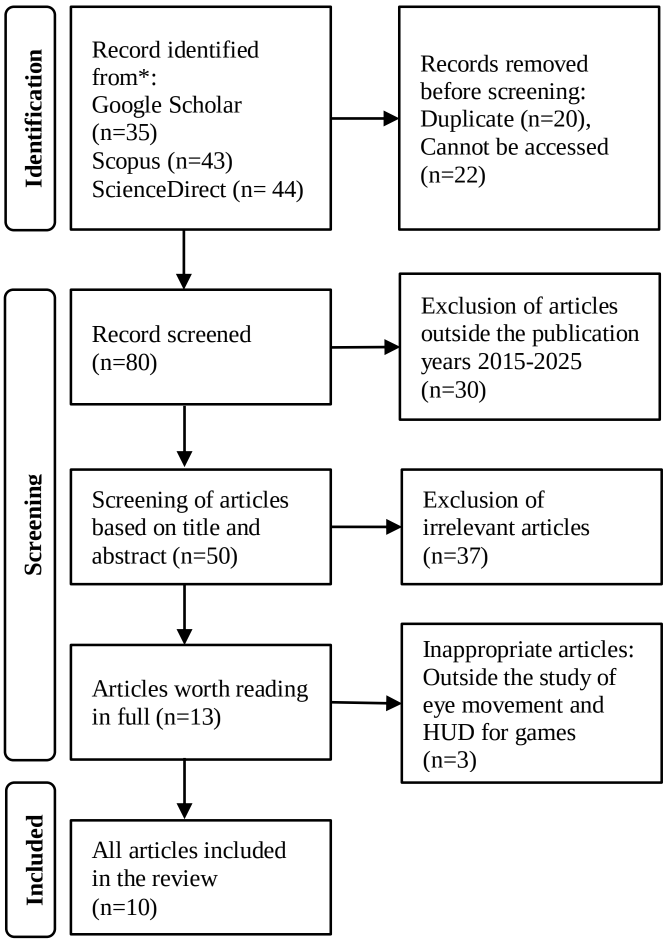

Figure 1. Diagram Prisma flowchart

The steps of the article identification process to screening taken from the Google Scholar, Scopus, and ScienceDirect databases are as shown in Figure 1. The search results in the databases Google Scholar, Scopus, and ScienceDirect yielded 122 articles corresponding to the keywords used. The next step involved the removal of articles before screening, with 20 duplicate articles and 22 inaccessible articles being eliminated. Then, in the initial screening process, there were

80 articles, and subsequently, the selection of articles outside the publication years 2015-2025 found 30 articles. So, there were 50 articles that could be screened by reading their titles and abstracts. From this process, 37 articles were found to be irrelevant. As the final stage of the screening, it was found that 13 articles could be fully read, and there were 5 articles that were not relevant to eye movement and HUD usage in games.

After the screening process, at the inclusion stage, there were 10 articles that met the study criteria, and further in-depth analysis of these articles was conducted. It should be noted that during the screening process, certain criteria were applied to ensure that the selected studies are relevant and of high quality. Types of criteria such as Inclusion and Exclusion are applied to obtain specific articles. In this section, the application of the PRISMA method is used as a guide for the systematic filtering process. The criteria are as follows:

1. Inclusion Criteria
   a. Articles written in English to maintain consistency in data collection and ensure accessibility for analysis.
   b. Articles published within the time frame of 2015-2025 to facilitate understanding of the latest developments in the selected studies.
   c. Research focus related to HUD in games of various genres using eye-tracking as the data collection method.
   d. Articles that are fully accessible to allow for evaluation and data extraction.
   e. Articles selected are only published in reputable journals and proceedings to ensure the quality of the article's content, as they have undergone peer review and evaluation.
2. Exclusion Criteria
   a. Articles published in languages other than English.
   b. Articles published outside the specified year range.

The focus of the research on eye movement without using HUD in games is not prioritized for collection, even though eye-tracking is used as the data collection method. This condition is a decision to maintain a clear and consistent focus of analysis. Nevertheless, studies outside that focus can provide valuable insights and enrich the discussions already established in this study.

The SLR employs a qualitative narrative synthesis rather than a quantitative meta-analysis due to the fact that the ten included studies differ in eye-tracker sampling rate (ranging from 50 Hz to 1000 Hz), task structure (passive video-watching versus live gameplay), and outcome metrics. Consequently, no pooled effect size or statistical aggregation across studies is computed. Cross-study heterogeneity is treated as a substantive finding in its own right and is discussed explicitly in section III and in the limitations, rather than statistically adjusted for, since the small number of included studies (n = 10) and the diversity of designs make formal heterogeneity testing (e.g., I^2) unreliable.

Study quality was appraised narratively rather than through a standardized scoring instrument (e.g., MMAT or a CASP checklist): each included study was assessed for whether it reported procedure of experience, eye-tracker sampling rate, a clear novice/expert grouping criterion, and inferential statistics for the fixation or saccade outcomes reported in Tables II and III. All ten included studies met these four criteria; none was excluded on quality grounds, and quality differences are therefore not a source of the outcome divergence discussed in Section III. A structured quality-appraisal instrument was not applied given the small and methodologically heterogeneous corpus, which is acknowledged as a limitation.

III. RESULTS AND DISCUSSION

The results of the literature data extraction show that there are 10 articles suitable for further study. As seen in Table 2, the data collection procedures conducted by previous studies vary, but it can be noted that there is a minimum recording duration using an eye tracker of 1 minute, as done by [21] and [22]. Furthermore, the procedures in the research experiments also differ, yet based on previous studies, there are some similarities, such as respondents being in a condition of watching recorded game [21] and [23]. For other experimental procedures, participants played games as instructed [22], [16], [24], [7], [18]. In addition, the research procedures implemented specific tasks that had to be completed during the experiment, according to the studies [22], [16], [25], [26], [17], [27].

For the measurement of eye movement characteristics, it can be seen in Table 3. Based on 10 extracted articles, the output of eye movement measurements includes fixations within the AOI and saccades within the AOI [21], [23], [22] [16], [25], [26], [17], [7], [18], [27]. The eye movement data of expert game players when interacting with the HUD, such as the mini map, is significantly higher at 1.21 sec/minute compared to beginner game players who have 0.61 sec/minute [18]. This condition contrasts with the findings of the study by [7], which showed that the eye movements of beginner players (FPS game, s = 139 (19) and RTS game, s = 184 (24)) were higher than those of expert players (FPS game, s = 114 (22) and RTS game, s = 143 (40)) when interacting with the HUD, as seen in the average fixation duration, $F(1,11) = 6.99$, $p = < .05$, h2p= .39. Another study also found that the interaction of players' eye movements with the HUD showed that beginner game players had higher values of 4.11 ± 2.27 compared to expert players 2.44 ± 1.06, as seen from the fixation ratio comparison, $t(24.618) = -2.946$, $p = 0.003$, $d = 0.969$ [16]. The results of this study are consistent with the research conducted by [25], which found that beginner game players had a 30% higher fixation percentage than expert game players, $F = 4.70$, $p = .03$, partial h2 =.08. A study by Liu Yang and colleagues [26] also showed that expert FPS players exhibited fewer fixations ($p = 0.007$) fewer saccades ($p = 0.006$) than non-FPS players. This indicates that experienced FPS players do not engage in random or excessive visual searching; they employ highly efficient visual strategies for processing spatial information about targets. The differences in the results obtained from the research are noteworthy and are caused by several factors, such as the different game genres used as experimental objects and the variations in measurement duration during the experiments. According to [7] the difference in game genres also determines the importance or lack thereof of information on the HUD for gamers.

As for the saccadic amplitude eye movements in gamers, there is a difference: expert players average 670–690 ms, which is faster in terms of response time than intermediate players who reach 820–850 ms [22]. A study conducted by Liu Yang and colleagues [26] found no significant difference in saccade amplitude between expert FPS players and non-FPS players ($F(1,61)=2.58$, $p=0.113$, $\eta^2=0.032$). Another study conducted by [25] shows that the percentage of saccadic eye movement speed in expert gamers is significantly faster, 32%, compared with beginner gamers at 27%. This indicates that expert gamers have an efficient and quick visual distribution in monitoring the game.

The findings summarized above are the reported empirical results of the individual primary studies; the interpretations that follow are this review's own synthesis and should be read as such, distinct from the primary studies' own conclusions.

Reclassifying the reported outcomes by genre rather than by a single “varies by genre” statement, three patterns emerge. In fast-paced, reflex-driven genres with dense simultaneous HUD information (FPS: [22], [26]; RTS: [7], [25]), experts show shorter fixation durations and faster, more frequent saccades toward the HUD, consistent with efficient, minimal-dwell information sampling. In racing simulation, where the HUD competes with a continuously moving primary visual target (the track), experts allocate significantly less overt attention to the HUD relative to the track than novices [16] and [17], indicating that HUD attention in this genre reflects a trade-off with primary-task demand rather than superior HUD scanning per se. In flight simulation [27], experts tend to look at the HUD more often than novices, who focus on what’s outside the cockpit. In the MOBA genre, where the HUD (mini map, hero status) is spatially fixed and low-frequency, expert-novice differences are attenuated or absent for mini map attention, though experts redirect attention toward specific HUD sub-regions (e.g., hero health) [18]. This pattern suggests that the direction of the expert-novice difference depends on whether the genre's primary task competes with or depends on the HUD for moment-to-moment decision-making, rather than on genre identity alone.

A plausible cognitive account of the expert-novice divergence is that expertise shifts visual search from serial, effortful scanning toward more automatic, parafoveal pickup of HUD information, consistent with the general expertise literature on perceptual-cognitive skill (e.g., faster and more selective visual search with practice). Under this account, novices fixate the HUD longer and more often because they have not yet automatized where and when task-relevant information appears, while experts have learned predictive scan paths that reduce foveal dwell time on the HUD without necessarily reducing information uptake. This interpretation is consistent with the patterns observed in[7], [16], [22], [25] and [17], but it was not directly tested by any of the included primary studies (e.g., via secondary-task load or gaze-contingent manipulation), so it is offered here as a candidate explanation for future confirmatory research rather than as an established finding of this review.

For interface design, these patterns suggest that HUD elements intended for rapid, repeated reference during fast-paced or competing-attention gameplay (FPS, RTS, racing) benefit most from designs that support brief, low-effort glances — for example, peripheral placement, high-contrast iconography, and minimal reading load — since expert players appear to rely on such glances rather than sustained fixation. Conversely, HUD elements in genres with fixed, low-frequency reference needs (MOBA-style mini maps and status panels) may tolerate denser information layouts, since expert-novice differences in attention to these elements are smaller. Designers targeting novice players specifically may consider onboarding aids (e.g., transient highlighting or guided attention cues) for HUD regions that expert players have learned to sample efficiently but that novices over-attend to at the cost of primary-task performance, consistent with the higher HUD fixation durations of novices reported in [7] and [16].

TABEL II
DATA COLLECTION PROCEDURES

Author	Design of The Research		
	Eye Tracker	Duration per Condition	Procedure of Experience
Krzysztof Zagata, Beata Medynska-Gulij dan Tymoteusz Horbiński [21]	Tobii X2 (sampling rate 60 Hz)	1 minutes	1. Watching 5 recorded videos of the game League of Legends. Videos 1, 2, and 4 contain game video clips focusing on the relationship between point symbols and game areas. Video 3 focuses on the relationship between the linear interpretation of point symbols and game areas. Video 5 is about game clips centered on the map for the spatial interpretation of the game with area interpretation regarding player interactions during gameplay. 2. No special treatment for the respondents. 3. Using spatial transitions from orientation points (symbols indicating various phenomena) to route knowledge to field knowledge.

			4. Task: Respondents must plan movements and actions using spatial knowledge obtained about the environment and stored on a mental map representing the area using orientation points
Liu Yang and colleagues [26]	EyeLink 1000 Plus (sampling rate 1000 Hz)	Total of 72 trials with 6 stages	1. Respondents played a simulation game adapted from the Counter-Strike 2 (CS2) workshop map "training_aim_csgo2", which is an aiming training map widely used by professional and amateur players. 2. During data collection, respondents used eye tracking, starting with calibration at 9 points. 3. The research design was that respondents were asked to look at the fixation cross, click on the yellow dot, wait for the red target to appear, and click on the red target as quickly and accurately as possible.
Juan Camilo Lopez dan Nadine Marie Moacdieh [23]	A Tobii Pro Fusion (sampling rate 120 Hz)	3 minutes	1. Watching 12 videos (each video lasting 30 seconds) from the perspective of a car driver. The video conditions include an urban environment, moderate traffic, and pedestrian levels. Cars move randomly on the road, driving normally thru intersections, then turning right or left until they pass thru the intersection again and stop. 2. The AR-HUD condition experiences various levels of transparency starting from 80%, 60%, 40%, 20%, and 0% or not visible. 3. Respondents watch 6 videos for each condition. 4. Respondents access a steering wheel and game pedal package just like driving a car connected to a computer.
Chung-San Yu and colleagues [27]	Applied Science Laboratory (ASL Series 4000) (sampling rate 30 Hz)	50 minutes	1. Respondents were asked to fill out a form with their personal information and were provided with information about the study that would be conducted. 2. Before the simulation began, the eye tracker was calibrated using three reference points placed around the cockpit instrument panel. 3. The pilot performs a 2 - 3-minute air-to-air maneuver simulation using a fighter jet simulator. 4. The primary task is to conduct a dynamic target pursuit mission under the following conditions: altitude of 20,000 feet, speed of 300 knots, heading of 50°. An enemy target suddenly appears on a heading of 90°, at the same altitude, and traveling at a speed of 300 knots. 5. The respondent's task is to locate enemy targets in the air (search), pursue the targets using combat maneuvers (pursuit), keep the targets in sight, lock onto them, fire their weapons until the targets are successfully destroyed, and—during the pursuit—the targets do not move in a straight line but constantly change their direction, altitude, and speed
Inhyeok Jeong, Takuma Nobuto, Naotsugu Kaneko, Takaaki Kato, Kimitaka Nakazawa [22]	Tobii 4c (sampling rate 90 Hz), and Pupil Core (sampling rate 60 Hz)	Experiment 1: Total 5 minute (1 minute trial repeated 5 times) Experiment 2: 1 minutes and 40 second test session (total 716 trial)	Experiment 1: 1. Respondents look at 9 black circles on the monitor for a visual similarity test for 5 seconds on each circle with a "Z" reading pattern. 2. Respondents play a first-person shooter (FPS) game on a computer 3. Respondents are only allowed to use the mouse for the gaming process. 4. Respondents are asked to shoot targets as quickly as possible in the pre-prepared game called AimLab. 5. There are two types of player expertise (very expert and intermediate).

			Experiment 2: 1. Play the game live together with 5v5 players to fight against enemies in the game Valorant. 2. Task: players must win as many games as possible with the condition that they can freely choose their weapons and characters. 3. Respondents are allowed to access the mouse and keyboard during the gaming process. 4. Using the KDA score in the game Valorant serves as the basis for evaluating a player's performance in the game. 5. There are two types of player skills (very skilled and intermediate).
John M. Joyce, Mark J. Campbell, Fazilat Hojaji, Adam J. Toth [16]	Tobii Pro Glasses (sampling rate 50 Hz)	8 laps of the circuit.	1. Respondents play sim racing games on the computer using Logitech G Pro Wheel-bases and Pedals. 2. The game conditions are set and controlled according to all levels of player expertise. 3. Driving speed is freely adjustable according to the player's preference. Using a single calibration point with an accuracy of 160^0.
Inhyeok Jeong, Kento Nakagawa, Rieko Osu, Kazuyuki Kanosue [25]	Pupil Core (sampling rate 60 Hz)	3 minutes	1. There is a game conditioning into 3 zones as a task that must be completed. 2. Players play the game at levels of easy task, moderate task, hard task.
Gisele C. Gotardi and team [17]	Head-mounted Eye Tracker (Applied Science Laboratory H6), (sampling rate 60 Hz)	Trial: 3 minutes; Testing: 3 laps	1. Respondents used eye tracking in gaming to record their eye movements. 2. Respondents played the game Gran Turismo 4 with the Autumn Ring Mini track type on PlayStation 2, and it was projected from multimedia BenQ (MX720) to screen 204 × 154 cm. 3. Respondents used the Logitech G27 steering wheel. 4. The driver must accelerate as fast as possible and complete 3 laps.
Loïc Caroux, Katherine Isbister [7]	SMI RED eye-tracker (sampling rate 50 Hz)	Trial: 5-minute, Testing: 15 minutes, followed by interview session	1. Respondents interact with the mouse and keyboard while playing games. 2. Respondents play games on a computer with a 17-inch monitor. 3. There is conditioning of the HUD design in FPS and RTS genre games
Lisa Castaneda, Manrita Kaur Sidhu, Jonathan J. Azose, Tom Swanson [18]	Tobii t60 - XL (sampling rate 60 Hz)	1 session of the game until completion	1. Respondents play games on a computer. 2. Using a 24-inch monitor. 3. Playing a MOBA genre game with the game object DOTA 2. 4. Pressing the "escape" key on the computer keyboard will restart the eye-tracker recording.

TABEL III
EYE MOVEMENT CHARACTERISTICS ON AREA OF INTEREST

Author	Stimulus	Outcome Measure	AOI
Krzysztof Zagata, Beata Medynska-Gulij dan Tymoteusz Horbiński [21]	*Video* from *game* League of Legends	First fixation on AOI, fixation duration (total time), fixation duration (total number), percentage fixation duration (total time)	Mini map
Juan Camilo Lopez dan Nadine Marie Moacdieh [23]	City Car Driving 1.5.9 driving simulator	Percentage of fixation duration on AOI, total fixation duration on AOI	Speed indicator, chevrons, and street turn indicator
Liu Yang and team [26]	Simulation game adapted from the Counter-Strike 2 (CS2) workshop map "training_aim_csgo2"	Fixation count, saccade count, fixation duration, saccade duration, saccade latency, saccade amplitude	undescribed

Chung-San Yu and team [27]	Fighter jet flight simulator	Percentage of fixation, average fixation duration, saccade velocity, saccade duration, attention distribution on AOI, pupil size	AOI 1: Head-Up Display (HUD); AOI 2: Integrated Control Panel (ICP); AOI 3: Right Multi-Function Display (RMFD); AOI 4: Left Multi-Function Display (LMFD); AOI 5: Outside Cockpit
Inhyeok Jeong, Takuma Nobuto, Naotsugu Kaneko, Takaaki Kato, Kimitaka Nakazawa [22]	AimLabs and Valorant	Fast saccadic, short fixation duration	1. Experiment 1: Mini-map, center area, Information1, and Information 2 2. Experiment 2: Other, mini-map, center area, Information1, and Information 2, horizontal gaze distribution, vertical gaze distribution
John M. Joyce, Mark J. Campbell, Fazilat Hojaji, Adam J. Toth [16]	Assetto Corsa Competizione (v1.8.18)	Fixation count on AOI, Average fixation duration on AOI, Total fixation duration on AOI	Track, lap time, circuit map, in-car information screen, tyre and brake temperatures, speedometer
Inhyeok Jeong, Kento Nakagawa, Rieko Osu, Kazuyuki Kanosue [25]	StarCraft	Fixation duration on AOI, saccade velocity, saccade number, saccade length	Area i: mini map; Area ii: number of destroyed enemy units; Area iii: selected unit or building; Area iv: number of resources; Area v: play area; Area vi: total score
Gisele C. Gotardi and team [17]	Gran Turismo 4 on PlayStation 2 (SONY)	Relative Number of Fixations (r-NUMFIX), relative Duration of Fixations (r-DURFIX), horizontal fixation variance, vertical fixation variance	Race lane, speedometer, chronometer, outside
Loïc Caroux, Katherine Isbister [7]	Call of Duty 4: Modern Warfare dan Star craft 2: Wings of Liberty	Fixations number on AOI, mean duration of fixation on AOI	1. Game RTS: map, units' management, action buttons, missions, resources. 2. Minimal attention such as locations of messages to the player, tip buttons, action buttons help. 3. Game FPS: Permanent attention like compass, guns, ammunition. 4. Minimal attention such as messages to the player, location of missions
Lisa Castaneda, Manrita Kaur Sidhu, Jonathan J. Azose, Tom Swanson [18]	Dota 2	Fixation on AOI	Mini map, character portrait, character level, active effect, health/mana, player stats, strength/intelligent, spells, items, gold, shop button, quick shop, courier status, protect tower, game status/KDA

IV. CONCLUSION

This SLR map research trends on HUD-driven eye movement in games and synthesizes the data-collection practices reported across the included studies. Consistent with the operational definitions set out in the Introduction, most previous research on this topic measures eye movement through fixation-based metrics (count, duration) and saccade-based metrics (velocity, amplitude, frequency).

Fixation-based outcomes differ between novice and expert players, but not in a single consistent direction: in FPS and RTS genres, novices show longer or more frequent fixations on the HUD than experts [7], [16], [22], [25], while in the MOBA genre this difference is largely absent [18]. Saccade-based outcomes are more consistent: across the studies that report them, expert players show faster saccade velocities than novice players [22], [25], a pattern consistent with more efficient gaze reallocation rather than, by itself, evidence of "better" eye movement in a general sense. These results should be read as a synthesis of ten studies rather than as a generalizable claim about expert or novice gaze behaviour beyond the genres and tasks these studies examined

The divergence in results across studies tracks genre-specific task demands more than any single protocol variable: fast-paced genres with competing visual targets (flight simulation, racing simulation, FPS, RTS) show attention trade-offs between the HUD and the primary task, whereas the low-frequency, fixed-location HUD elements typical of MOBA titles show smaller expert-novice differences (see Section III). Regarding data-collection procedures, no two included studies used an identical protocol, but recurring practices include the use of desktop computer displays as the game medium and a minimum recording duration of approximately one minute per condition, reflecting the millisecond-level temporal resolution of the eye trackers used. These recurring practices are reported here as a descriptive baseline for researchers designing future protocols; they have not been validated against each other and do not constitute a tested standard.

This article has several limitations. First, it examines eye movements specifically as influenced by the HUD and does not extend to gameplay attention more broadly; future reviews could broaden this scope. Second, the search was limited to Google Scholar, Scopus, and ScienceDirect; databases such as IEEE Xplore, PubMed, and ACM Digital Library were not searched, which may have excluded relevant HCI- or engineering-focused studies and introduces a risk of database coverage bias. Third, because only studies indexed in these three databases and reporting statistically significant or codable eye-tracking outcomes were retrievable through the search strings in Table I, this review cannot rule out publication bias toward studies with positive or significant expert-novice findings; null-result studies with HUD eye-tracking designs may be under-represented in the included set. Fourth, the search strings combined multiple synonym clusters (e.g., “HUD”, “eye tracking”, “visual attention”); alternative terms such as “gaze behaviour”, “interface attention”, or platform-specific terms (e.g., “mini map”) used in isolation may have retrieved additional eligible studies not captured here. Fifth, the ten included studies are methodologically heterogeneous in eye-tracking hardware (50–1000 Hz sampling), task structure (passive viewing versus active play), and outcome metrics, which is why this review reports a qualitative narrative synthesis rather than a pooled statistical estimate; the genre-level patterns identified in Section III should be read as hypotheses for future confirmatory research rather than as effect sizes. Sixth, the small number of included studies (n = 10) limits the precision of the genre-based classification proposed here, and the descriptive protocol synthesis in Section III has not been validated experimentally.

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