RUNNING HEAD: Quiet Eye in FPS Esports

Effect of Target Differentiation, Prioritization, and Environmental Clutter on Quiet Eye Duration in First Person Shooter Esports: A Brief Report Pilot Study

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Abstract

The burgeoning prominence of esports underscores its increasing relevance in sport and performance psychology. To enhance its integration into scholarly discourse, established cognitive research paradigms should be applied. In this study, we focused on first-person shooter esports, identifying specific variables unique to this domain and examining their impact on quiet eye (QE) duration—an indicator strongly correlated with successful performance. Using eye tracking equipment, we analysed gaze data related to the QE, the final fixation point preceding a motor response. Our pilot sample (n = 9) participated in three block trials exploring the effects of environmental clutter, target differentiation, and target prioritization on QE duration. Paired t-tests compared mean QE duration between experimental tasks and control trials with single targets. While trend effects of environmental clutter and target prioritization were observed, none reached statistical significance. These findings echo certain aspects of existing esports literature, particularly regarding the reduced prominence of QE in scenarios involving multiple targets. Acknowledging study limitations, we offer recommendations for future research to deepen understanding of cognitive processes and performance outcomes in esports.

Keywords: Esports, First-Person Shooters, Quiet Eye, Eye Tracking

Esports has witnessed exponential growth in popularity over the past two decades, outpacing other entertainment industries in audience engagement and revenue generation (Li, 2017). Recent increases in popularity have led to larger tournament prize pools, increased advertising and economic opportunities through sponsorship and television marketing (Zhang & Liu, 2022). For instance, esports revenue in 2015 was estimated at $278 million and rose to around $500 million just a year later (Li, 2017), with more recent global industry valuations of $24.9 billion US dollars in 2019 (Ahn et al., 2020; Welsh et al., 2023). Competitors compete for monetary prize pots that in excess of $30 million (McLeod et al., 2023; Welsh et al., 2023).

Correspondingly, the research landscape surrounding esports as a performance domain is rapidly expanding to mirror its global rise (Reitman et al., 2020). This surge in interest has led to the adoption of contemporary research paradigms and technologies within esports literature (see Dale et al., 2020). To firmly establish esports within the scholarly community, it is essential to leverage existing theories and constructs, thereby demonstrating its value and untapped potential within the realm of performance psychology. Moreover, integrating robust and well-established paradigms from traditional sports literature will lay a solid foundation for comprehending the psychological underpinnings of successful performance in high pressure esports.

With the parallel rise of technology being used in research, eye tracking has become much more prominent, and with it has come a better understanding of gaze behavior within performance psychology. The concept of the quiet eye (QE), referring to the final fixation or tracking gaze at a task-relevant location before the initiation of movement (Vickers, 2007), reflects expertise-related differences in fixation behavior (Vickers, 1996b). QE is a phenomenon seen at all levels of expertise, and is characterize by a fixation at a task relevant location/object prior to the engagement of a motor response. Duration, onset and offset are all greatly impacted by performers expertise (Lebeau, et al, 2016; Mann et al., 2007).

QE duration is measured as the time between onset and offset, with onset defined as fixation within 3 degrees of visual angle of a task-relevant location lasting at least 100 milliseconds and offset marked by deviation by at least 3 degrees of visual angle from the fixation point's center (Vickers, 1996a; 1996b). Coined by Vickers (1996a; 1996b) after observing basketball players making free throws, QE finds broad applicability across sports like shotgun shooting, golf, and football (Hüttermann et al., 2018; Vickers, 2016; Vine et al., 2012), with a consistent correlation between QE duration and increased performance (Nibbeling et al., 2012; Piras & Vickers, 2011; Rienhoff et al., 2013). For instance, the benefits of QE appear to be trainable as Vine and Wilson (2010) reported that a QE-trained group performed better in a golf-putting task than an explicit retention (i.e., a motor skill taught in an explicit manner) group and a high-anxiety group (see also; Vine et al., 2011; Vine & Wilson, 2011; Vine et al., 2014). The transferability of QE effects across different sporting contexts was observed by Broodryk et al. (2023) who found positive effects of QE duration on kicker performance in rugby union players. Vine et al. (2014) considered a number of different potential explanations for the QE effect in sport performance, including that QE instructions maintains goal-directed focus at key pressure points for performers as the importance of the location of visual attention is re-affirmed (see also Wilson & Richards, 2011), and that QE is linked to emphasis on implicit motor learning that is less susceptible to external distraction (see Vine et al., 2013). Findings from sports psychology have been replicated in other fields which involve focused and precise motor responses. Professionals from fields such as surgery and law enforcement decision-making with a longer career and more experience typically displayed longer QE durations and onset and offset changes associated with more effective performance (Causer, 2014; Vickers & Lewinski, 2012).

Meta-analyses have shown significant differences in QE duration between novices and professionals, insofar as longer QE duration is associated with better performance, as well as between successful and unsuccessful performances (Lebeau et al., 2016; Mann et al., 2007), strongly supporting its generalizability across sports, occupations, and cultures. However, critiques have emerged regarding the core definition and measurement methodology of QE. One of the primary reasons for criticism includes the outdated equipment used in the early studies that established a QE effect. Modern equipment developments allow for more intricate and accurate data, and such equipment is also a lot more available and widespread for use in scientific research allowing for a broader range of perspectives and empirical nuance to be added to the understanding of QE and how it might be linked to performance across contexts. Recommendations propose reducing the required duration, considering advancements in eye-tracking technology (Dahl et al., 2021). Moreover, scholars have criticized the overemphasis on the relationship between longer QE duration and performance without exploring underlying mechanisms (Gonzalez et al., 2017; Krajník, 2022). Coined the 'efficiency paradox,' researchers advocate for deeper investigations into why prolonged fixation correlates with higher levels of performance (Mann et al., 2016). Klostermann and Hossner (2018) suggest that longer QE durations may result from an increased need to inhibit alternative solutions, driven by the randomness of practice typical among experienced athletes (Horn et al., 2012). In other words, expert athletes have a wider breadth of experience from which to draw from when in situations that require problem-solving processes. . Sharpe, Obine, et al. (2024) discussed arousal reappraising through interventions to reclassify threats as challenges, and anxiety responses as preparing to step up to challenging situations. The present study may help us to better understand what esport specific scenarios high level performance athletes perceive as threatening. Further psychological factors could help explain the differences observed between novices and professionals in esports and the present study aims to focus on one that boasts a large repertoire of research in traditional sport.

The present study aims to explore how QE duration is affected by difficulty or complexity of specific engagement variables in First Person Shooter (FPS) esports. Existing QE literature often focuses on traditional sports and single-target experiments, which may not fully represent the multitarget scenarios common in FPS games. The performance-enhancing effect of QE might be less applicable in multitarget scenarios (Krajník, 2022). Change in QE duration appears to be due to an instinctual reaction to change strategies, prioritizing speed of reaction over accuracy. While literature indicates longer QE durations for more complicated shots, they do not always translate to improved performance outcomes (e.g., golf-putting shots; Walters-Symons et al., 2018). While earlier onset of fixation is typically associated with longer QE durations, in more cognitively demanding tasks a later offset may be observed to maintain the benefits of longer QE durations (Dahl et al., 2021). This delay allows for perceptive techniques such as scanning and reflexive saccades to scan the environment for enemy presence. Extended QE duration is suggested to allow for greater critical motor preparation time. This includes selection of task solution and refining the required movement parameters for the appropriate motor response (Moore et al., 2012).

Further theories approach QE like a facilitation of filtering visual information, to highlight task relevant stimuli, suppress saccade amplitude and velocity, and filter out distracting stimuli or emotional response (e.g., Gallicchio et al., 2018; Goldberg et al., 1986; Vickers, 2009). The programming and visual attentional control hypothesis both follow a line wherein the QE is used as a buffer period. This allows the brain to engage the elaborate neural pathways needed to formulate a plan based on experience, filter distraction, mitigate emotional involvement, and fine tune the motor response sequence.

Therefore, the present study investigated three variables unique to esports that could significantly impact QE duration. Firstly, prioritizing between low, medium, and high threat targets may decrease QE duration, reflecting increased cognitive load (H1), as research supports the impact of anxiety on QE durations, wherein speed is favoured over accuracy (Eysenck et al., 2007; Brimmell et al., 2019). Secondly, differentiating between team members and enemies could increase QE duration due to the need for more accurate shots (H2). Lastly, targets presented in cluttered environments may lead to longer QE durations as they require greater attentional control (H3).

Method

Participants

A total of 9 participants were recruited for the study through volunteer sampling. However, one participant had to be excluded from the analysis due to a significant lack of gaze data recorded (65%), rendering many trials impossible to analyse. The error occurred due to a calibration fault whereby the eye tracker did not properly record the participant's gaze data leading to a subthreshold output not suitable for analysis. The final sample consisted of 8 participants (*n* = 8; *M* Age = 23.38, *SD* = 8.62; 5 male, 2 female, 1 other), who completed a single experimental session. No incentives or rewards were provided to participants for taking part in the study. All remaining participants met the inclusion criteria, either having clear unaided vision or corrected vision compatible with the eye tracker utilized in the study. Participant experience varied predominately on their hours played in FPS games and the level of competition to which they played on a regular basis. For example, some participants were members of university level competition teams, while others were individuals with a minimum of 2000 hours of experience with team-based player versus single player FPS games. Familiarity with Rainbow 6:Siege was not measured as the situations presented were nonspecific enough that they could occur in any FPS game. All players operated on a skill level equivalent to the top 30th percentile in their preferred FPS game. In terms of Poulus et al.'s (2024) novel classification system for categorizing the eliteness of participants in esport studies, while there was a range of standard and experience across our sample, on average, the participants would be classified as *non-elite* (Step 1) with *limited success* and *moderate experience* (Step 2 contextualization).

This study was a pilot investigation, not intended to confirm results. Instead, its goal is to lay the groundwork for a larger future study, depending on the discovery of clear effectiveness trends and the practicality of conducting the below noted methodology within this target population. We used a between-subject design and considered our current resource limitations, such as a limited number of competitors in the region (see Lakens, 2022).

Materials

Gaze behaviour was recorded using a head-mounted Tobii Pro Glasses 2 mobile eye tracker with four sensors, operating at a frequency of 50 Hz (www.tobii.com/). The eye tracker's high-definition capability (1920x1080 pixel; 25 frames per second) allowed for frame-by-frame analysis using Tobii Pro Lab Analyser. Before each recording session, the fit of the glasses on each participant was verified. Interchangeable nose rests were used as needed to ensure that the tracking cameras were positioned at the correct angle and distance from the participants' eyes. This was confirmed through a calibration test involving a circular stimulus, during which participants were instructed to fixate on the center for up to five seconds. The calibration stimulus card was held by the researcher and placed at the top of the monitor used to display the stimulus, so that the calibration also incorporated the distance between the participant and the screen. The monitor size used to display stimuli was a 1920x1080 18-inch screen and PsychoPy software was employed to time the display of stimulus and synchronize the eye tracking data.

Initiation of motor response was prioritized over completion of engagement due to uncontrollable variables, such as cursor start locations and individual differences in mouse sensitivity preferences. A manual method for determining fixation onset and duration was chosen due to the nature of the sample and eye tracker's sampling rate of 50Hz, which necessitated subjective analysis to determine fixation initiation. The Tobii analysis software provided tools to accurately detect onset and offset of the QE. Areas of interest were limited to the chest and head of the target stimuli to reflect higher expertise levels in first-person shooter games, where shots to these areas typically result in more damage. This approach diverged from traditional binary accuracy measurement, allowing for nuanced distinctions in accuracy levels.

Procedure

Participants were initially briefed on the study procedure and provided with an information sheet and consent form for review and signing. Institutional ethical approval was obtained from the lead university. Participants were seated in front of a laptop, and the Tobii eye tracker was provided for them to wear. Calibration was then conducted using the Tobii recording software's built-in procedure. Any questions regarding the procedure or participant expectations were addressed during this briefing phase. Following preparation, participants completed a practice trial comprising 10 items representing each of the three variables, with the option for repetition if necessary. Subsequently, three block trials were conducted, each corresponding to one of the variables: environmental clutter (14 items), target differentiation (10 items), and target prioritization (23 items). Stimulus images, sourced from the match replay system in the game 'Rainbow 6: Siege,' depicted standardized scenarios tailored to each variable. Stimuli were presented for three seconds, followed by a blank black screen to act as a rest screen, rest screen duration was randomized between 3-5 seconds to maintain participant alertness. Participants were asked to respond to stimuli by moving the mouse cursor to the highest priority target in each stimulus image and clicking on them, examples of all target types were displayed and labelled in the practice trial block. This covered all variables because in environmental clutter there is only one target and in differentiation there is one enemy target and one friendly target. In target prioritization there were two enemy targets, one of which was always higher priority than the other.

Actors staged scenarios wherein friendly and enemy players were highlighted by blue and orange glowing outlines, respectively, replicating various games' techniques for distinguishing between friend and foe. This method aimed to compensate for participants' potential lack of familiarity with the game, as identifying characters typically relies on repeated practice and game knowledge. Each block of trials utilized experimental stimuli, contrasted with control variants presenting a single target at a standardized distance from the player against a relatively plain background.

The Control stimulus was a single target displayed at a consistent distance. The exact target and location of the target changed from trial to trial, but it was always a single humanoid target presented face on to the player. The same is true for the Experimental stimulus. For example, in the Environmental Clutter Condition trials, targets were placed at varying locations in the cluttered scene, but always at a consistent distance from the player which matched the distance used in control trials.

In Prioritization and Differentiation Experimental trials, two targets were placed either side of the players crosshair. In prioritization trials, one target would be visibly a greater threat than the other and players were prompted during these trials to move the mouse cursor over the highest priority and ‘shoot’ them by clicking on them. Three target threat levels were made visible, high threat targets were an enemy player pointing their gun towards the camera. Medium threat targets were enemy players using surveillance cameras and, therefore, unaware of their surroundings; however, this type of player could very suddenly become a high threat target on their own. Lastly, a low threat target was an enemy player in a down-but-not-out state that needed to be picked up by one of their teammates; this type of player could become a high threat, but only if aided by one of their teammates.

Data Analysis

Accuracy was not directly measured in this study; however, participants were encouraged to prioritize accuracy to ensure data reliability. This approach facilitated a normalized speed-accuracy trade-off variation, rather than imposing a specific trade-off through the measurement of shot success rate (Sutter et al., 2021). While accuracy is commonly recorded in QE studies to differentiate successful versus unsuccessful performance, the present study focused on exploring the effect of variables on quiet eye duration, without establishing links between duration and successful performance, as seen in previous research. Including accuracy measurement would have expanded the study's scope significantly. Additionally, the study involved participants with varying expertise levels, potentially leading to a wide range of accuracy rates across participants, which could skew results. More specifically, fixation was only classified as onset when the participants' gaze locked on either the target's head or chest. This is because these areas are considered the best focus areas among competitive players since they yield the best results when targeted. The approach used here was not to distinguish different classifications of accuracy for the purpose of measurement, but to justify the areas of interest on the target. In QE research, it refers to fixation at a task relevant location or object and in the present study we highlight the chest and head of the enemy target. Data analysis involved paired *t*-tests to compare mean quiet eye duration between experimental conditions and matched control trials and the level of significance was set at $p < .05$.

Results

The small sample size of the study heightened the impact of outliers and skewed data. However, normality assumptions were met through mathematical and visual assessments of skewness and kurtosis, along with a Shapiro-Wilks test across all variable levels.

Environmental Clutter. A paired *t*-test showed no significant difference in quiet eye duration (*M* = 19.63; *SD* = 25.54) between cluttered and non-cluttered environments, $t(7) = 2.17$, $p = .066$. The 95% confidence interval ranged from –1.73 to 40.98, supporting acceptance of the null hypothesis regarding environmental clutter.

Target Differentiation. A paired sample *t*-test indicated no significant difference in mean quiet eye duration (*M* = -2.90; *SD* = 27.63) between scenarios with a single target and those with a target alongside a friendly player, $t(7) = -0.30$, $p = .780$. The 95% confidence interval ranged from –26.00 to 20.20, demonstrating non-significance.

Target Prioritization. The final paired sample *t*-test revealed a non-significant difference in quiet eye duration (*M* = 21.61; *SD* = 27.35) between single target trials and multiple target trials with varying threat levels, $t(7) = 2.24$, $p = .060$. The 95% confidence interval ranged from – 1.25 to 44.48, indicating a result close to the significance threshold but insufficient to reject the null hypothesis.

Discussion

The primary aim of this study was to investigate the quiet eye phenomenon within the context of esports, focusing specifically on variables unique to first-person shooter (FPS) games.

Given the established link between longer quiet eye duration and enhanced performance in esports, we examined target prioritization, differentiation, and environmental clutter to validate the theory in the esports domain. However, the results of the present pilot study indicate that while target differentiation had minimal impact on quiet eye duration, prioritization and environmental clutter effects indicated a pronounced, albeit statistically albeit statistically non-significant. To address the non-significant findings, we echo Walters-Symons et al. (2018) in suggesting that pre-programmed cognitive processes may underlie these results. Specifically, task difficulty changes and cognitive workload management may be activated before fixation onset. For instance, in billiards, adjustments in force production occur post-fixation onset, contrasting with angle calculations performed prior to shot execution (Williams et al., 2002). Similar observations were noted in golf putting on varied terrains (Wilson & Pearcy, 2009).

The findings of our study align with those of Krajník (2022), indicating that the performance-enhancing effects of the QE do not extend to scenarios involving multiple targets. Krajník's research revealed that when two targets were presented, accuracy in shots at the second target did not benefit from differences in QE duration or onset time. Furthermore, target prioritization trials did not result in longer QE durations when engaging the first higher-priority target compared to when only a single target was present. This can be attributed to the cognitive processes involved in threat assessment, which occur before fixation on the first target. Reflexive and scanning saccades are utilized to identify targets, followed by the processing of stimuli in a task-solution sub-space, allowing for rapid reaction time and accuracy (Sutter et al., 2021). Further, despite the findings of this study, the application of the QE to esports remains highly beneficial (see Sharpe et al., 2024; Trotter et al., 2023, for examples). Factors influencing QE duration in traditional sports also hold validity in esports, although some may be more relevant than others (Krajník, 2022). For example, task difficulty has been found to increase the duration of QE in darts throws where random target changes resulted in increased QE duration. When implemented in coaching and talent scouting, the QE effect exhibits strong consistency in terms of performance across contexts in the wider research literature (Lebeau et al., 2016). The broader the applicability of this occulomotor behaviour pattern (i.e., QE), the more reliable it becomes in predicting performance across various fields. Once talent is identified, assessing perceptual-motor skills aids in evaluating aptitude and pinpointing areas for improvement during training. While methods for training the QE have been explored (Horn et al., 2012), further research focusing specifically on esports is warranted.

Limitations and Future Directions

Our study's non-significant findings should be interpreted with caution, primarily due to the limited sample size inherent in this pilot investigation. As pointed out by Button et al. (2013), underpowered studies not only reduce the chance of detecting a true effect but also decrease the likelihood that a statistically significant result reflects a true effect. Therefore, while our results do not provide strong evidence for our hypothesized cognitive mechanisms, they also do not definitively rule them out. The absence of significant findings in our study aligns with the broader issue of replicability in psychological science (Open Science Collaboration, 2015). However, as emphasized by Lakens (2017), non-significant results can still contribute valuable information to the field, especially when considered in the context of effect sizes and confidence intervals. Our observed trends, although not statistically significant, potentially point to underlying cognitive mechanisms worth further investigation, and align with prior work that has demonstrated some utility in QE under differing contexts (i.e., high pressure esport scenarios; Sharpe, Leis et al., 2024; Sharpe, Obine, et al., 2024), while also providing some insight into the possible allocation of cognitive resources shared between the stimuli-directed and goal-directed systems (as per the Attentional Control Theory; Eysenck et al., 2007). As such, our findings do not discredit the value of continuing this line of study with an appropriately powered sample size.

Given the controlled nature of our study, still images were employed to ensure the precise presentation of required scenarios on demand. While this method provided control, alternative approaches such as video stimuli could offer a more comprehensive depiction of engagement scenarios in FPS games. For instance, sound cues, known to impact quiet eye duration, were not incorporated in our study. Research indicates that target pre-cuing reduces quiet eye and movement preparation time (Horn & Marchetto, 2021), highlighting the importance of sound in environment awareness, including in-game cues and teammate communication (Curtin et al., 2022). Additionally, Klostermann et al. (2013) found that spatially pre-cued targets reduced quiet eye duration, suggesting optimization of information processing. However, such studies have not been replicated in an esports context, where situations are dynamic and environmental stimuli abundant. While our study found no significant differences between trials, the absence of audio perceptual factors may limit the generalizability of results. Establishing significant effects of target pre-cuing in FPS esports settings may necessitate reaffirming the present findings using more holistic match representations.

Previously established literature on traditional sports suggests that the distance to the target impacts the duration of the QE. This effect was controlled for in our study by presenting all targets at the same distance from the player. However, research has not explored whether this effect translates to esports, along with other variables established in QE literature. Our study aimed to investigate the effects of variables more exclusive or prominent in esports contexts. Future research could aim to cross-culturally apply existing influencing factors of QE to esports, adding credence to the theory's application and subsequently its implications on training, self-assessment, and talent scouting. In addition to our study, many previous experiments on QE in esports have opted to use computerized tasks to maintain control over variables and significantly boost replicability. However, some criticisms of this approach highlight differences from studies on traditional sports. For example, QE research on golf, basketball, and rifle shooting athletes often requires participants to complete self-paced tasks, reducing the pressure of time and allowing for a greater degree of accuracy. Due to the short period in which stimuli were presented to participants, and the encouragement to be "as fast and accurate as possible," some participants favored one aspect over the other. Those who prioritized accuracy would have produced overall longer quiet eye durations, as shown in previous QEesports studies (Dahl et al., 2021). Even utilizing a more naturalistic, observational methodology and having players compete in a game or tournament while wearing an eye tracker would struggle to allow for self-paced action. Nonetheless, this could be a potentially valuable avenue for future research. The variables utilized in our study were chosen as they were common scenarios in most FPS games and would subsequently be readily observable in a real match.

The current study design could be significantly improved by addressing several key areas. Firstly, the sample size of 8 participants is insufficient for robust statistical analysis and limits generalizability; a larger sample would enhance the likelihood of detecting more robust effects.

Methodological improvements could include counterbalancing the order of block trials to control for possible order effects, further standardizing the visual characteristics of stimuli across conditions, and mitigating practice effects through more extensive practice sessions or multiple testing sessions. The control conditions could be expanded to more closely match experimental conditions, particularly in target prioritization trials. While Quiet Eye duration is the primary focus, incorporating additional eye-tracking measures would provide a more comprehensive understanding of gaze behavior.

To address potential confounds related to game familiarity, either participants with specific Rainbow 6: Siege experience could be recruited, or a more generic FPS environment could be sampled. Moreover, future studies could benefit from the application of Poulus et al.'s (2024) classification system for identifying levels of eliteness in esports samples at the research design stage to aid with more targeted participation recruitment that provides more specific participant esports background experience detail and will serve to enhance the replicability and generalizability of empirical work in this field. Environmental variables such as time of day, lighting, and noise levels should also be controlled. Additionally, collecting data on individual differences in cognitive abilities and incorporating measures of test-retest reliability would strengthen the study. Finally, considering the inclusion of physiological measures like heart rate variability (see Welsh et al., 2023) or skin conductance could offer insights into arousal levels during the different trial types.

Conclusion

The present study aimed to explore several variables common among first-person shooter action esport games as potential influences on QE duration, with the goal of providing insights into more esport-specific training options. Utilizing a 50Hz eye tracker, there were no statistically significant differences across environmental clutter, target differentiation, and target prioritization variable conditions. However, trends in the present pilot data suggest that environmental clutter and target prioritization should be furthered explored in future sufficiently powered empirical trials. These findings partially replicate those of previous studies attempting to replicate QE research in an esport context. Despite the acknowledged limitations of the present pilot study, we hope that this work can stimulate and inspire similar future research on QE effects in esports by employing higher frequency eye tracking equipment, recruiting a fully-powered and higher-level expertise sample, and trials that could de designed to be even more representative of FPS match scenarios.

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