LUNDS UNIVERSITET

DEPARTMENT of PSYCHOLOGY

“Hot hand” in Esports: Quiet Eye Does Not Generalize to Multiple Targets in a Computerized Task.

Jan Krajník

Master’s Thesis (30 hp)

Spring 2022

Supervisor: Mats Dahl

Abstract

The effect of ”Quiet Eye” (QE), an oculomotor behavior predicting improved performance, has been identified in a variety of sports studies in the past 30 years. Most commonly, longer QE durations and earlier QE onsets results in higher accuracy of the participants. Recently, Dahl et al. (2021) have shown that these findings can be generalized to esports, a newly emerging field of performance psychology. The current study attempted to replicate these findings, while also establishing whether they can be applied to situations where multiple targets are presented on the screen. In a computerized task, participants were asked to hit the target/s presented on the screen while their eye movements were measured using a high-end remote eye-tracker. We found that longer QE duration and later QE onsets coincided with better performance in a 1-target task. In the 2-target task, QE was present for the first target but not the second. As such we conclude the performance improving parameters of QE in 1-target tasks cannot be generalized for situations where multiple targets are present.

Keywords: Quiet Eye, Eye Tracking, Esports, Gaming, Vision

Introduction

At the highest level, sports teams and athletes are trying to gain an edge over their competition in any way they can and while talent, physical ability, and strategy are of undeniable importance, precise hand-eye coordination is what can decide between winning and losing. Although most of the athlete's training is focused on strengthening the body, the eyes and the patterns through which they operate should not be overlooked. One of such patterns, the Quiet Eye (QE), has been one of the most prominent oculomotor behaviors that predicts good performance in sports. Recently, however, there has been an effort to extend the findings from sports studies into a newly emerged field of performance research: esports.

Quiet Eye and its application in sports

QE is defined as the final fixation of the eye, which lasts at least 100ms and is located within 3 degrees of visual angle from the center of a target for a given motor task. Importantly, QE duration commences before the start of the motor task and lasts all the way until the eye deviates from the target by 3 degrees of visual angle (Vickers, 2016). In essence, this means that the longer one focuses on the object they want to hit, the more accurate they are going to be. It has become a significant research topic mostly through the studies of Joan Vickers who has demonstrated its significance and coined the term after observing that the occurrence of QE improves performance in a series of studies focused on basketball free throws (Vickers, 1996a, 1996b, 1996c). Since then, the presence of QE has been found in a plethora of studies stretching across various “targeting” sports activities such as golf putting (Vickers, 1992), basketball free throws (Rienhoff et al., 2013; Rienhoff et al., 2015), hockey goaltending (Panchuk et al., 2017), biathlon shooting (Vickers & Williams, 2007), archery (Gonzalez et al., 2017), and dart throwing (Vickers et al., 2000). The major commonality between the mentioned studies is that they focus on investigating a single QE occurrence for one stationary target (such as a golf hole in golf putting). This, however, is not always the case as shown by studies focusing on trap shooting (Causer et al., 2010) and multiple QE occurrences in a basketball throw (Vickers et al., 2019).

It is important to note that the presence of QE itself is not enough to account for increased performance however, in most of the studies it is the total duration of QE and the onset of QE which makes the difference with longer QE durations and earlier QE onsets indicating better accuracy. The relevance of such findings has been supported by large scale meta-analytical studies (Kredel et al., 2017; Lebeau et al., 2016) and as such is considered as a strong determinant in explaining the difference between expert and novice performances. It is important to note however, that while QE helps us to differentiate between rookies and professionals, it also predicts general performance reasonably well. This is shown in a meta-analysis by Lebeau et al. (2016) that revealed large effect sizes of QE-expertise (d=1.04) and medium effect sizes for the QE-performance (d=0.58).There is also a strong suggestion that such ocular behavior can be introduced as part of a practice in order to increase performance. In fact, Lebeau et al. (2016) have demonstrated that QE training significantly elongates the QE duration of experts when compared to individuals without any training, which in turn also leads to improved performance for the trained individuals when compared to the untrained individuals.

Current methodological and theoretical issues regarding Quiet Eye

While QE research is appealing and stretches across various disciplines, several criticisms have been raised towards it being the singular explanation in identifying eye patterns of athletes (Dalton, 2021; Gonzalez et al., 2017) . Several studies have raised questions about its underlying mechanisms, as it is not entirely clear how exactly longer QE durations improve performance across different activities. Currently, there are several proposed mechanisms through which QE might operate. First however, it is important to highlight some elementary preconceptions of the relationship between the eye's fixation and attention. The two concepts of human cognition are closely related (Moore & Fallah, 2001; Moore & Fallah, 2004) as directing your gaze towards a target greatly increases the motivational salience of that object and suppresses the stimuli in the peripheral locations, as seen in the decreased number of saccades outside the fixated location (Goldberg et al., 1986). While this helps us to establish some basis behind why QE duration may be predictive of better performance, the assumption that simple fixation results in greater attention, however, is not sufficient for explaining QE phenomenon in full.

It has been hypothesized that longer QE duration gives us more time to assemble and activate the complex neural system underlying the execution of precise motor movement (Vickers, 2009). In other words, it gives performers more time to process the critical actions including planning, initiation, and finalization of the task (Vickers et al., 2019). So called "programming hypothesis" is supported by several studies that show that QE duration increases together with the increased difficulty of the task at hand. Such findings were shown in increasingly more difficult billiard shots (Williams et al., 2002) and dart throws with random target changes (Horn et al., 2012). Klostermann et al. (2013) also support this notion in their "ball-throwing" experiment. In their study they manipulated the duration of the QE by presenting the target at different timings (short and long) as well as locations (random and predictive). The results of their study show that when the cognitive demands of the task are high (short and random presentations) the effect of a longer QE duration on performance is much more prominent.

In a more recent explanation, Vickers (2016) outlines that QE and its effect on performance can be explained by the interaction between the dorsal attentional network (DAN) and the ventral attentional network (VAN). When seeing a target, the DAN projects the information from the occipital to the parietal lobe and helps us to maintain sustained attention. During QE it is hypothesized that we suppress the incoming signals from the VAN, which projects information to the frontal areas of the brain through the temporal lobes, including the hippocampus and amygdala, which oversee emotional and memory processing. As such, the memory of a suboptimal past performance for example, can inhibit the sustained attention of the DAN, and it is hypothesized that expert performers can block out the signals from VAN more efficiently (Vickers, 2016). The notion that QE is the indirect estimation of how well one can inhibit external information has also been supported by Klostermann et al. (2014), who argue that while the “motor programming” hypothesis explains the effect of QE on performance well, it does not shed light on the differences between novice and expert performers. Especially when we take into consideration that with continuous practice motor control processes become automatized over motor learning (Schmidt & Lee, 2018). Klostermann et al. (2019) extend this hypothesis by proposing that expert performers show longer QE durations due to a larger demand for inhibitory responses as they are aware of a larger number of alternative solutions for the demanded task.

It is apparent that while the current research tries to pin down QE as the singular explanation for improved performance, the underlying mechanisms behind QE are anything but singular. This might in part be due to the complexity of the interaction between the visual and the motor system but also due to the notion that there can be multiple oculomotor behaviors for a given motor action. This criticism was partially addressed by Vickers et al. (2019) who have shown that QE occurred separately for multiple motor actions, that is for catch, arm preparation, arm flexion, arm extension, and ball release during a basketball throw. Additionally, QE research and eye tracking research in general struggle with balancing out the ecological validity (i.e., viewing conditions that closely resemble the studied sport) and experimental control (i.e., accuracy of measurements) as presented in the systematic review by Kredel et al. (2017). A big proportion of the studies focusing on sports often use monocular mobile eye-trackers with lower sampling rates (30Hz, 60Hz). This not only affects the overall accuracy of the measurements, but also makes QE more challenging to measure, due to its strict definition. However, within esports, a newly emerging field of performance research, ecological validity and experimental control do not present the same concerns.

Esports, their relevance, and Quiet Eye

Esports are no longer a niche venue reserved for a minority of video game aficionados, in fact it has gained immense interest in the last decade. While being valued at $130 million in 2012, it is estimated to be valued at $1.79 billion at the end of this year with approximately 1.8 billion people being aware of the term worldwide (Block & Hack 2021; Newzoo 2019). In psychological research it has been getting traction as well, mainly with regards to sports and performance psychology as there is an ongoing attempt to integrate this growing industry within these fields. This is reflected by the number of the published articles about performance in esports. Between the years 1992 and 2011 a total number of 10 articles were published, while between 2011 and 2019 this number grew all the way to 52 (for review see Ramirez et al., 2020).

With a growing interest comes a demand in establishing a solid theoretical as well as methodological foundation to fully support the rapid increase in publications. Nevertheless, when it comes to eye tracking research the number of studies using this method in relation to the field of esports is sparse. So far there are only a handful of studies that tried to incorporate eye tracking to study esports performance i.e. (Bickman et al., 2019; Nagel, 2017) and even fewer focusing on first-person shooters (FPS) that are of interest regarding this investigation (Dahl et al., 2021; Khromov et al., 2019). As such, there is a clear need of incorporating the strong research methods seen is sports psychology, such as the QE paradigm, into the newly emerging field of esports. It ought to be stressed that in esports research there is a lesser problem with ecological validity as compared to usual sport research conducted in a lab, since the conditions closely resemble the ones that esports players usually find themselves in during their performances, that is, sitting in front of a computer. As such, expanding the existing sports research by incorporating sports activities seems highly adequate and a natural step in broadening the literature about the QE.

Dahl et al., (2021) do exactly that by designing an experimental task that closely resembles a first-person shooting (FPS) games genre. FPS game are a highly cognitively demanding type of games which require the player to navigate through the game environment both in terms of location of their in-game character and the direction the character is looking at (Gerling et al., 2011). In their experiment the participants were asked to “shoot” a target using a mouse in a fast-paced “aiming game”. Consistent with previous studies, longer QE durations were associated with higher accuracy, however the study found no support for the relationship between performance and earlier QE onsets. Nevertheless, finding the connection between QE duration and performance was the first step in establishing that the QE paradigms used in sports can be generalized to esports scenarios. FPS esports athletes, however, are only rarely ever asked to “hit” just one stationary target. In fact, the environments and situations they must navigate through are much more intricate than this, which is what the current study will try to partially address.

The current study

The current study will attempt to replicate the findings of Dahl et al. (2021) as well as expand the research paradigm by an additional condition which should provide information of whether findings from 1-target designs can be generalized to 2 targets. For the 1-target task we hypothesize that longer QE durations will result in higher accuracy. Additionally, we expect there to be no significant difference between hits and misses with regards to QE onset. For the 2-target task we plan to take an exploratory approach, with the main intention of seeing whether there is a separate QE for each of the targets. Additionally, we will be looking to confirm whether longer QE durations and earlier QE onsets will be predictive of better performance when multiple targets are present. This way, the current thesis should not only extend the findings of Dahl et al. (2021), but also address some of the unclarities regarding multiple QE occurrences for a given motor task.

Methods

Participants

A total number of 23 participants took part in the study. However, since 2 datasets were incomplete, the final sample size was $N = 21$ ($M_{age} = 25.32$, $SD_{age} = 5.11$). In total, 10 males and 11 females took part in the study. They were recruited by opportunity sampling as there were no prerequisites to participate in the study other than 20/20 or corrected vision. They were compensated for their participation with cinema tickets.

Materials

The stimuli were presented on an EIZO FlexScan EV2451 screen with a resolution of 1920 x 1080 pixels (52.8 x 29.7cm) which was positioned 63cm away from the participants. The distance between the screen and the participants was maintained using a chin and headrest (Tobii's standard). Participants' eye movements were recorded using the Tobii Pro Spectrum eye tracker (rmware 2.2.3, 600 Hz). The participants used a Logitech PRO Gaming mouse (M/N:M-U0052) with mouse sensitivity of 8 chosen from the basic Windows mouse sensitivity scale of 0 (not sensitive at all) to 20 (very sensitive). The tracking of the mouse movements was carried out using PsychoPy (60 Hz PsychoPy v. (2021.2.3)). The critical stimuli consisted of circular targets that were presented on a mid-gray background (8-bit gray value of 128). The presented targets consisted of a red dot with a diameter of 1 deg, and a blue dot with a diameter of 0.2 deg that was placed in the center of the red dot.

Design and Procedure

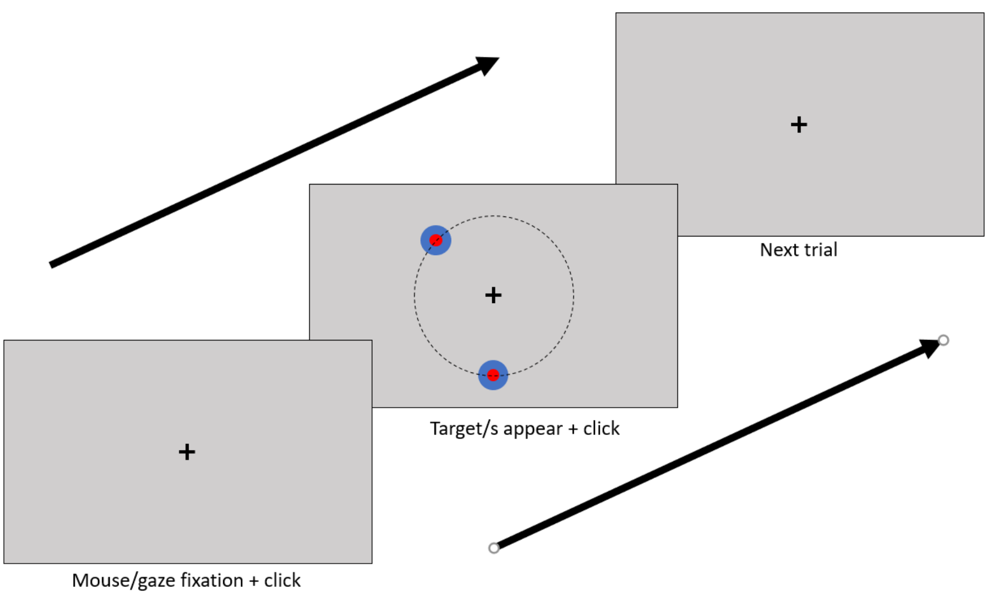
The experiment consisted of two conditions: a static and a dynamic one. Each condition was further divided into three blocks based on how many targets were simultaneously within each trial. The number of targets increased by one per block from one target being presented in the first block up to the total of three targets being presented in the last block of each condition.

In the task itself (see Figure 1), the participants were instructed to "shoot" the target/s as "accurately and as quickly as possible" by navigating the mouse cursor to it and clicking on it.

Each trial started with participants fixating both their eyesight and their mouse cursor on the central fixation cross. After the participant clicked on the fixation cross, a target/s appeared at a centrally located circle with a radius of 3 deg that was not visible to the participants. In both conditions the target/s had a chance of appearing at 8 evenly spaced locations on the circle's perimeter. In the static condition they disappeared after a set amount of time which was regulated by the success rate of the participants. In the dynamic condition however, as soon as the target/s appeared they started moving at a constant speed in an outward direction following a line between the central fixation point and their relative position at the beginning of the trial and consequently disappeared at the perimeter of a larger non-visible circle.

Figure 1

Sample trial for 2-target task



Note. An example showing the timeline of a single 2-target trial is shown. First the participants had to fixate their mouse and gaze on the center fixation cross. After clicking on the cross, two targets appeared at random locations. Regardless of the accuracy, after clicking twice they were immediately redirected to the next trial.

In both conditions the difficulty was scaled using the 1-up-3-down staircase method, which was meant to level out the participants' success rate at 79.4% (Leek, 2001). In the static trials this affected the amount of time the targets were visible for, while in the dynamic trials it determined the distance between the inner and the outer circle. This meant that with each consecutive hit the task became progressively harder as the targets had gradually lower exposure times and vice versa for when the participants missed the target. It is important to note that once the participants try to "shoot" the target/s with the mouse the target/s disappeared before reaching the terminal time, regardless of whether they hit them or not. In order to gamify the task and maintain the levels of motivation and attention, the participants hit rate (expressed as % of target's hit) would be displayed at the top right of the screen. Furthermore, participants were able to take breaks at any point of the experiment as each trial had to be commenced by clicking and fixing their eyesight on the central location.

First, the participants were seated in front of a computer and were verbally briefed about the nature of the experiment and asked to read and sign the informed consent form. Afterwards, basic instructions about how to proceed with the experiment were given to them as well as information that they can take breaks at any moment throughout the experiment. Subsequently, they were led through the calibration process. If successful, they could then proceed with the experimental task itself. Once they finished all the experimental tasks, they were asked to remain seated until all the participants in the room were finished. Ultimately, they were debriefed about the nature of the experiment, how they might contact the experimenters if they desire to do so and compensated for their time with a movie ticket. No ethical problems were identified within the scope of the research as the participants were informed of their rights, namely that their participation was voluntary, that they had the right to withdraw as well as the fact that the collected data would remain confidential.

Data Analysis

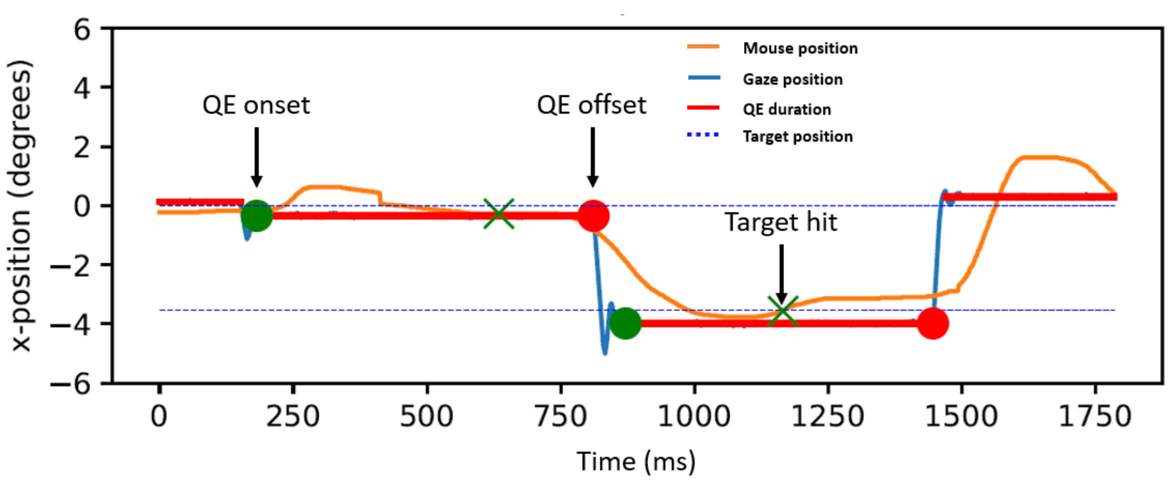
Due to the limited scope of the current research only the data from the 1-target and 2-target static conditions were used in the analysis. An I2MC algorithm (Hessels et al., 2017) was used to identify the fixations and to transform the raw eye-tracking data into the desired variables. These were most importantly the QE duration and the QE onset. Additionally, mouse data were collected to acquire the values required to assess whether the participants hit or missed the target (dichotomous variable) as well as to measure the distance (D) between where the participants clicked and the actual center of the target (continuous variable). This was done to follow the recommendations by Williams et al. (2016) and Dahl et al. (2021) who highlighted that accuracy does not have to be only expressed as a hit or miss variable, but also to assess how far from the "bullseye" the participants clicked. The analysis was done using the lme4 package for linear mixed effects modelling (v1.1-29; Bates et al., 2015).

Results

In total, 3465 trials were analyzed, with 1099 observations in the 1-target condition and 2366 observations in the 2-target condition. The time progression of a sample trial describing how participants typically navigated their eyes and mouse, the start and end of each QE session, as well as whether they hit the target can be seen in Figure 2.

Figure 2

Example of a typical trial



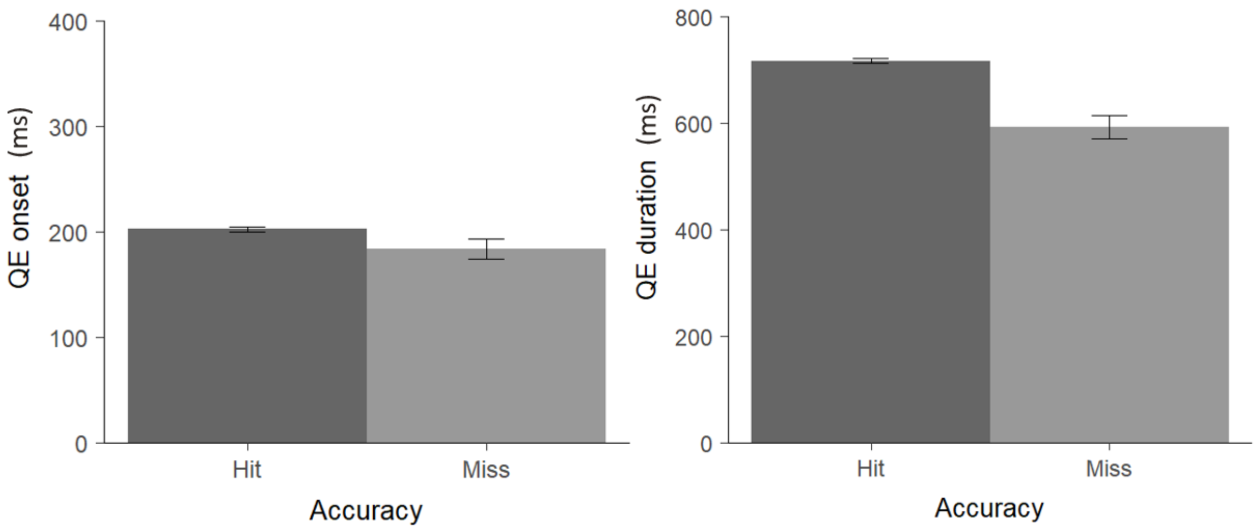
Note. This figure demonstrates a typical 2-target trial. It depicts the position of the participants mouse and gaze in relation to the position of the target over time (milliseconds) alongside the x-axis. Additionally, it shows at what point does QE starts (green dot) and ends (red dot) and whether, and at what point, did the participant hit the target (green or a red cross).

1 - target task

For the 1-target task QE durations were significantly longer for hits (*M* = 717.76 ms, *SD* = 137.21 ms) than for misses (*M* = 594.27 ms, *SD* = 198.34 ms); β = 123.49, *t*(1087) = 7.99, $p < 0.001$, (*SE* = 15.46). Additionally, QE onsets were significantly later for hits (*M* = 202.91 ms, *SD* = 81.02 ms) than for misses (*M* = 182.89 ms, *SD* = 86.50 ms), although the effect was not as strong as in the QE duration, β = -20.03, *t*(1094) = 2.19, *p* = 0.03, (*SE* = 9.16), see Figure 3.

Figure 3

QE onset and QE duration in 1-target task

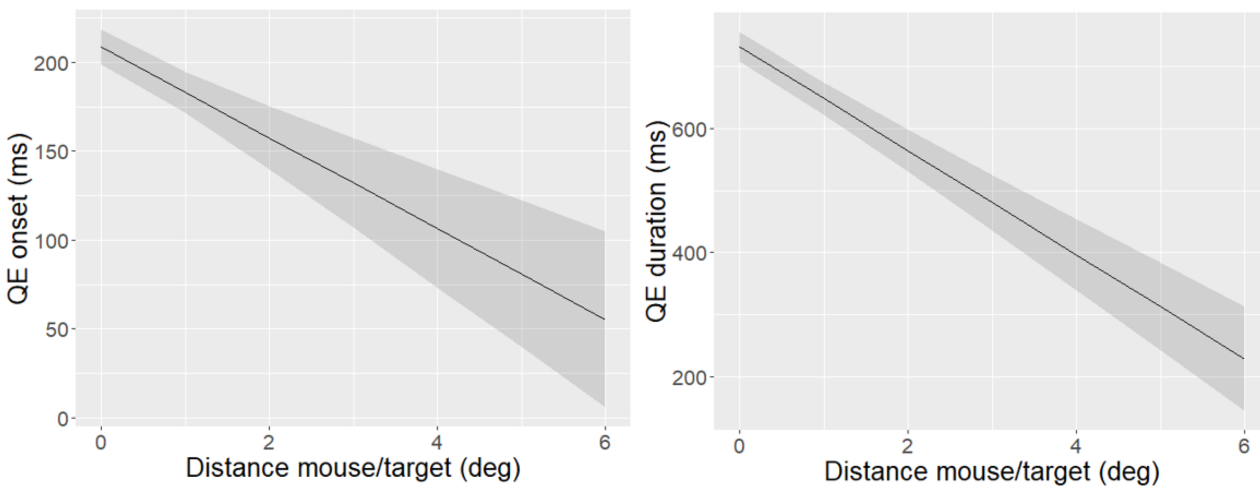


Note. A relationship between the accuracy expressed as either “hits” or “misses” is shown in relation to the QE onset and the QE duration (error bars show standard errors).

Furthermore, we use linear mixed effects modelling to try to assess whether the total distance between the center of the target and the place where participants clicked could predict QE onset and QE duration. When expressing accuracy as the total distance (D) from the center of the target, there was a main effect of D on both QE onset [β = -25.57, $t(1090.20) = -5.87$, $p < 0.001$, ($SE = 4.35$)] and QE duration [β = -84.14, $t(1084.12) = -11.65$, $p < 0.001$, , ($SE = 7.22$)]. This shows that participants that clicked closer to the target had longer QE durations and later QE onsets (see Figure 4).

Figure 4

QE onset and QE duration as a function of distance



Note. The figures display a linear fit between distance from the center of the target (degrees of visual angle) and QE duration and QE onset. The shaded margins display 95% confidence intervals.

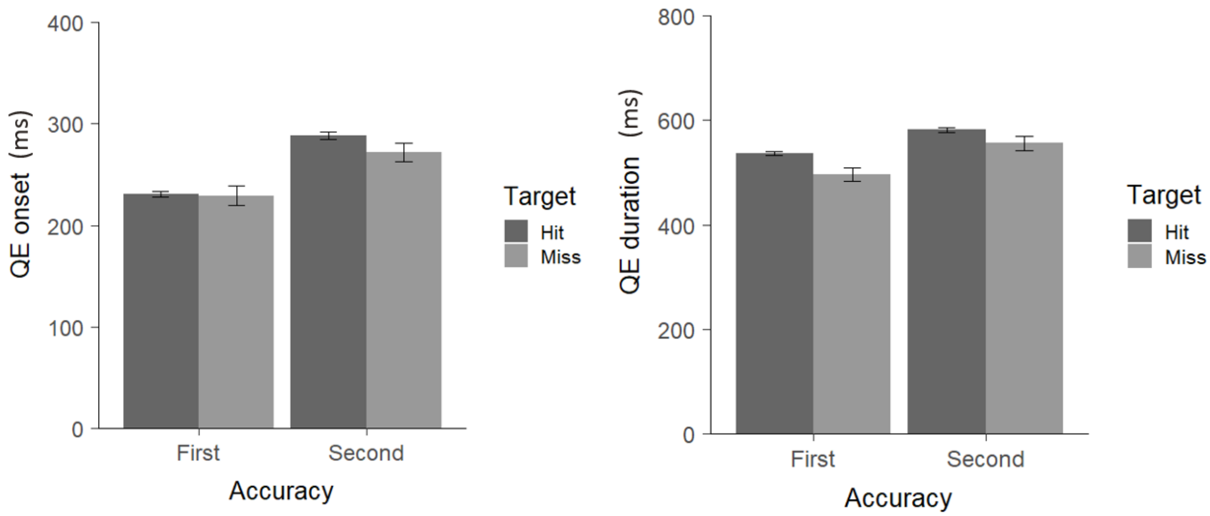
2 – target task

In comparison to the 1-target task, QE duration in the 2-targe task was not significantly different between hits and misses for neither the first target [β = 21.71, $t(2350.19) = 1.74$, $p = 0.082$, , ($SE = 12.51$)], nor the second target [β = 18.43, $t(2346.40) = 1.58$, $p = 0.114$, ($SE =$

11.66)]. This also applied to QE onset as the difference between hits and misses for both the first target [β = 4.52, *t*(2345.35) = 0.47, *p* = 0.638, (*SE* = 9.55)] and the second target [β = 21.72, *t*(2338.90) = 1.84, *p* = 0.066, (*SE* = 12.51)] was not significant (see Figure 6).

Figure 6

QE onset and QE duration in the 2-target task

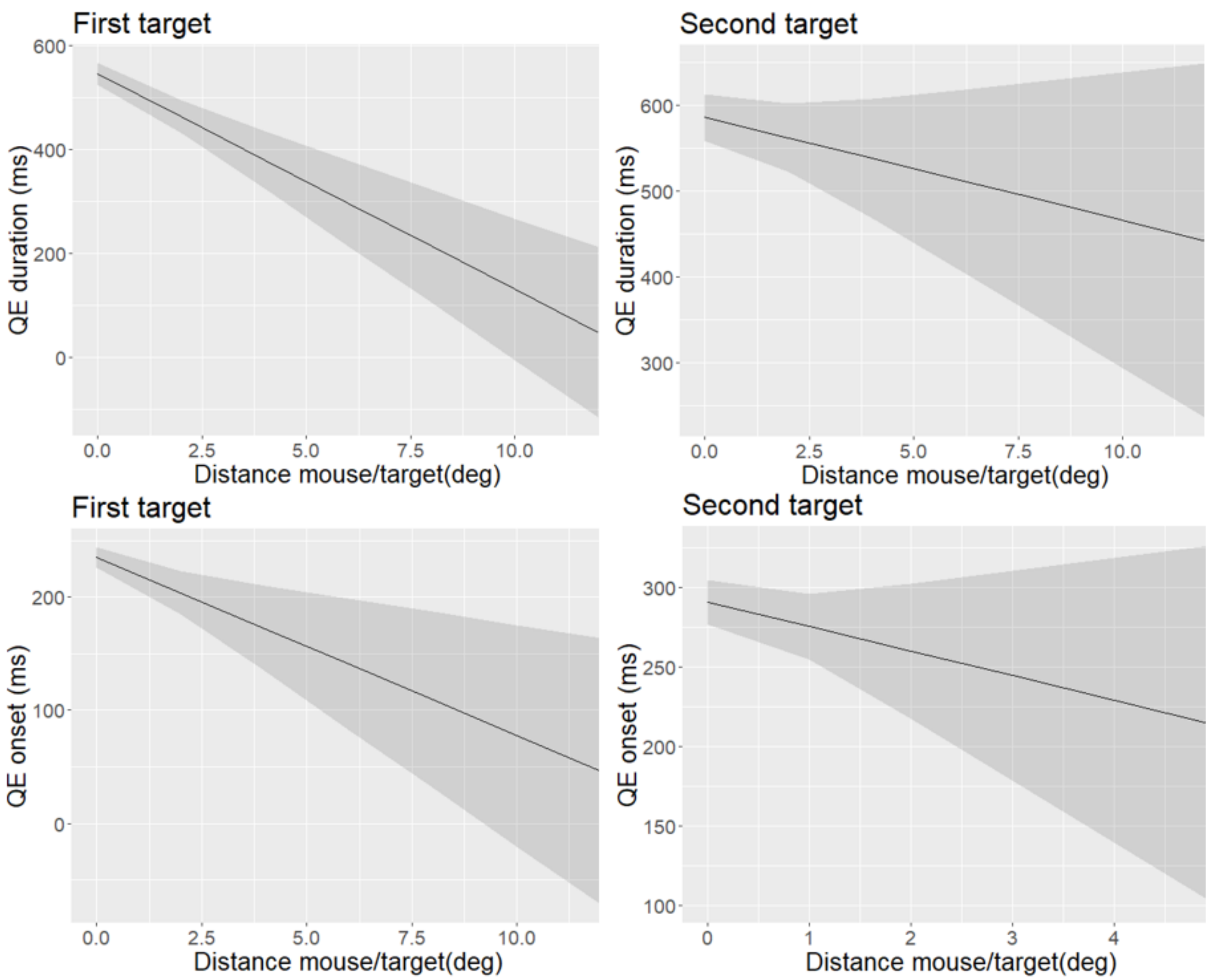


Note. "Hits" and "misses" are compared separately for first and second target in terms of both the QE onset and the QE duration.

Similarly, to 1- target task we used linear mixed effects modelling to see whether the total distance (D) could be a significant predictor of QE onset and QE duration. This analysis showed that D had a main effect on QE duration for first target [β = -41.45, t(1244.76) = -5.84, *p* = <0.001, (*SE* = 7.10)] but not the second [β = -11.97, *t*(1088.63) = 0.47, *p* = 0.182, , (*SE* = 8.97)]. For QE onset there was a similar trend, as there was a main effect of D for the first target [β = -15.80, *t*(1255.03) = -3.08, *p* = 0.002, (*SE* = 5.13)] but not the second [β = -15.45, *t*(1087.16) = -1.26, *p* = 0.207, (*SE* = 12.24)]. These results suggest that more accurate clicks were a result of later QE onsets and longer QE durations for first but not the second target (see Figure 7).

Figure 7

QE onset and QE duration as a function of distance, separate for first and second target



Note. The figures display a linear fit between distance from the center of the target (degrees of visual angle) and QE duration and QE onset for both the first and the second target. The shaded margins display 95% confidence intervals.

Discussion

The current study set out to investigate the presence of an oculomotor behavior that indicates improved performance across multiple sports known as the “quiet eye” (QE) in a computerized task that closely resembled a first-person shooter (FPS) videogame. This was done by attempting to replicate the findings of Dahl et al. (2021) who have explored whether the usual QE parameters that improve performance in sports, such as longer QE durations (Lebeau et al. 2016; Kredel et al. 2017; Vickers, 1996a, 1996b, 1996c) and earlier QE onsets (Causer et al. 2010; Mann et al. 2007; Panchuk et al. 2017), applied to an esports setting. In their study, they have found that more accurate performance could be explained by longer QE durations and that there is no effect of QE onset on accuracy. Apart from replicating these results, the current study also investigated whether the results presented by Dahl et al. (2021) can be generalized to scenarios where multiple targets are present on the screen.

The current research has replicated the previous results of Dahl et al. (2021) only partially. Consistently with previous research, QE durations in the 1-target task were longer for “hits” than for “misses”. Unlike previous studies however, QE onset were later for “hits” than for “misses”, which goes against the results from the sports studies (Causer et al., 2010; Mann et al., 2007; Panchuk et al., 2017) as well as the esports studies (Dahl et al., 2021). In the 2-target tasks, neither the QE onset nor the QE duration was significantly different between the “hits” and “misses” in both the first and the second target. When investigating accuracy as the total distance (D) from the center of the target there was a main effect of QE onset and QE duration only for the first target but not the second. These results largely suggests that the regular QE parameters that usually lead to improved performance cannot be generalized to scenarios where multiple targets are present at the same time.

At the current state of the research there is no good explanation for why QE onsets were associated with better accuracy in the 1-target task. It is something which is rarely ever mentioned in relation to good performance in the sport research as longer QE duration are most often achieved by earlier QE onsets (Vickers et al., 2016). Nevertheless, the current results suggest that it is not the earlier QE onsets, but the later QE offsets that influence the QE duration. Participants that lingered on the target for a longer duration after executing the critical task of "clicking" were more likely to hit the target. While later QE offsets were previously linked to improved performance in studies investigating the differences between novice and expert performers (Klostermann et al., 2014; Klostermann et al., 2018; Panchuk et. al. 2017), they were not included as a measure in the current analysis and as such are required to be explored further in the future.

In relation to the 2-target task, it seems that QE onset and QE duration was only indicative of performance for the first target, when accuracy was expressed as a continuous variable. This needs to be investigated further as the vast majority of QE research focuses on singular motor action with singular QE occurrence, which is also one of the most common criticisms of the QE research. Causer et al. (2010) investigated QE in a task where multiple targets were present, however, they computed QE for both targets together. Vickers et al. (2019) on the other hand, measured QE separately for multiple motor behaviors, in the end however, there was only one target present. Due to the slight differences between the experimental designs, drawing conclusion with reference to our study is challenging. There is, however, a clear need to focus on occasions where multiple targets and multiple possible QE occurrences are present, especially in the esports setting as it is a common occurrence that athletes must attend to multiple targets at once. After all, one of the greatest advantages of generalizing sports research into esports settings is that the experimental conditions closely resemble the environment in which sport athletes usually find themselves in, while maintaining good experimental control. And although the current task is still far from the 3D environments that the athletes usually navigate through, we think that this is a step in a good direction.

Although the current study expanded on the previous findings it struggles with similar theoretical and methodological issues that were presented by Dahl et al. (2021). In their study, they highlight that there might be a tradeoff between speed (how fast the participant hit or miss the target) and accuracy (how far from the center of the target they were). While the participants were instructed to “hit the targets as quickly and as accurately as possible”, there is a good possibility that some of them preferred one aspect over the other. As such, a possible way of interpreting the current findings from the 1-target task is to suggests that QE onsets were later for hits rather than misses since the participants optimized on accuracy rather than speed. It is important to note that we tried to accommodate for this limitation by including the 1-up-3-down staircase method (Leek, 2001). When participants optimized on speed at the cost of accuracy the time for which the next target would be present on the screen was progressively longer. In a similar way, participants that optimized on accuracy at the cost of speed would then be forced to click faster. Although this could have accounted for some of the interindividual differences between the participants, a further investigation is needed to explore the relationship between speed and accuracy.

The measure of accuracy is another aspect that needs closer investigation. We followed the recommendations to include a measure where the variable would be expressed as the total distance from the center of the target (Dahl et al., 2021; Williams et al., 2016). We agree with including this measure, especially when considering the novelty of the esports/eye-behavior research, as it helps to establish larger variety of factors that could influence performance. Nevertheless, it is important to note, that when accuracy was treated as continuous variable it produced different results for the 1st target of the 2-target task, as opposed to when it was calculated as a dichotomous variable. While it is always important for esports athletes to hit the target that they are aiming at, accuracy within the target itself i.e., hitting a "bullseye" instead of the target periphery is of equal importance. At the current state of the research, it is arguable whether one should be preferred over the other as currently there are no available suggestions for which one of the two interpretations would represent FPS games more closely.

Lastly, the sample used in this study consisted mostly of university student with variable experience with videogames or FPS games. It was neither the intention nor within the scope of the current investigation to explore the interindividual differences between experienced and non-experienced players. At this moment, however, there is no way of telling how much the presence of both novice and experienced players affected the data in the current analysis, although this could be tackled in future research. After all, the presence of QE is more indicative of the difference between expert and novice performance rather than of general performance (Lebeau et al. 2016). Furthermore, investigating scenarios with more complex designs, (i.e., moving targets, 3D environments) should move the current research closer to imitating the conditions that players find themselves in most often.

Conclusion

We have partially replicated the "QE effect" usually found in sports in a computerized task and shown that these findings do not generalize to tasks where multiple targets are present on the screen. Longer QE durations and later QE onsets were associated with improved performance only when 1 target was present. There was no effect of QE duration or QE onset for the second target in the 2-targets task. We conclude that further investigation focusing on complex tasks, speed/accuracy tradeoff, as well as seeing differences between novice and expert gamers should be considered in research to come.

Acknowledgments

I would like to extend my greatest thanks to all the people that have supported me on the road through the academic world for the past 6 years. Especially, I would like to thank my supervisor for his words of wisdom, my family for their words of kindness and support, and most of all Andra who has always been there for me.

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