Quiet eye vs. noisy brain: The eye like the brain is always active – comment on Vickers

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TA COMMENTARY

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ABSTRACT

The Quiet Eye (QE) period is a pervasive phenomenon in many aiming tasks. The number of published reports exploring the QE has grown substantively following the seminal work by Vickers (e.g., 1992, 1996). However, our understanding of the mechanisms underpinning the phenomenon remains limited. There is an abundance of descriptive data, yet few attempts to use experimental manipulations to identify causal mechanisms and even fewer efforts to employ neuroscience methods to identify areas of the brain activated during the QE. We can only speculate in regards to the extent to which the phenomenon is linked to motor programming, on-line visual control, arousal control, or other possible mechanisms, which may work together or in isolation. While early attempts to employ QE training methods have reported significant benefits, the absence of a mechanistic explanation necessitates caution in currently recommending widespread use of such interventions.

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As highlighted by Vickers (2016), the scientific study of Quiet Eye (QE) has grown substantially since her identification of the phenomenon two decades ago. This growth is due to the prevailing robustness of empirical findings and her significant innovation in continuing to create novel situations and contexts to examine the phenomenon. The body of work outlined by Vickers (2016) has inspired many scientists and is of the highest quality in regards to the level of sophistication of the methods employed and the intellectual rigor of the ideas examined. Moreover, research on the training of QE has the potential to have significant impact on performance and learning across many domains. In this short reply to her review article, I focus my attention on just a few key areas which in my mind would benefit from further research endeavour.

What is the QE? Methods and definition

Vickers (2016) suggests that QE should be measured in situ. While collecting data in situ may present the optimal scenario, the phenomenon may be reproduced in the laboratory using more controlled experimental tasks (see Gonzalez, Causer, Miall, Grey, Humphreys, & Williams, 2015b). Provided that the QE is reliably reproduced in the laboratory and the task retains an action component linked to gaze behaviour it should be possible to explore the underlying mechanisms under more controlled settings. This latter approach may be desirable, if not essential, if we are to better isolate the mechanisms involved in the QE using neuroscience methods. The use of fMRI, EEG/ERP and TMS methods remains problematic when whole body movements are involved. While data collection in situ needs to continue, we may need to accept the fact that more controlled tasks are needed to enhance our theoretical understanding of this phenomenon.

Another limitation is that the definition of QE has emerged from the operational capacities of the main measurement system used to quantify the phenomenon (i.e., the ASL mobile eye system). Consequently, the definition is somewhat arbitrary rather than being linked to any underlying mechanism (see Gonzalez, Causer, Miall, Grey, Humphreys, & Williams, 2015a). The mobile eye system has a measurement error of ± 1 degree and a sampling rate of 50 or 60 Hz. The operational definition of QE is that the gaze remains within a visual angle of 3 degrees from the target for a minimum period of 100 ms. The issue is that the eye is never actually 'quiet'; it is always on the move since there are continuous drifts, tremors and microsaccades (see Gonzalez et al., 2015a). We have limited understanding of what, if any, functional role these small and rapid eye movements have and the extent to which they may impact on the QE. High resolution eye trackers now sample at upwards of 500 Hz with a spatial resolution under 0.1 degrees. Although it may be difficult in the short term to use such high resolution systems in situ, they may certainly be used effectively under more controlled laboratory conditions. Advances in measurement sensitivity may enable us to revise and refine our operational definition of the QE.

As highlighted by Vickers (2016), we need clear and objective criteria to define the links between QE and performance. However, I disagree with Vickers (2016) that the QE period should only be discriminating on 'hits' and 'misses'. If the QE is strongly associated with aiming performance it should be able to differentiate performance in a continuous rather than a dichotomous manner. For example, in archery, a longer QE should be evident on a shot that scores 7 compared to another that scores 8 (out of 10) not just 'hits' and 'misses'. Similarly, the QE should be able to discriminate a putt that falls 10 cm short of the hole from one that rolls 2-3 metres past the target rather than those which are holed or not. The use of regression analyses rather than traditional difference testing may offer greater sensitivity in examining the links between QE and performance across the board. We need to better identify how sensitive the QE measure is and to what extent can it predict various levels of performance on aiming tasks.

Is the QE relevant across all tasks? Limiting scope and identifying mechanisms

The seminal work on QE used targeting tasks such as golf putting and the basketball free throw. In such instances, the target is often static, but not always so as in shotgun shooting (e,g., Causer, Holmes, & Williams, 2011), and there is nothing to focus on other than the target. Clearly, during an aiming task one assumes that information is being extracted from the target which facilitates performance. However, it may be that focusing on the target may be less important than maintaining a stable gaze. Is there a change in performance if gaze is diverted slightly off centre yet remains stable?

The greatest shortcoming in this area of study is the paucity of work that has attempted to better identify the mechanisms that underlie the QE phenomenon. It has been suggested that the QE period reflects motor programming, on-line motor control, and arousal or attention control, yet all of these suggestions remain largely uncorroborated (Gonzalez et al., 2015a). Some researchers have used experimental manipulations to test theoretical assumptions (e.g., Klostermann, Kredel, & Hossner, 2013; Williams, Singer, & Frehlich, 2002), whereas others have used neuroscience methods to identify neural activity during the QE period (e.g., Mann, Coombes, Mousseau, & Janelle, 2011). Yet, more theoretically-driven research is needed using cross-disciplinary approaches if we are to enhance our understanding of the QE period. Limited benefit may be gained from more descriptive reports using different population groups and tasks.

The issues of identifying causal mechanisms are compounded in tasks that involve interception of objects in flight and interactions with teammates and opponents. It could be argued that the QE is only relevant in aiming tasks with limited applicability to other tasks. For example, in sports like soccer and tennis it has been well reported that elite athletes are more likely to use 'visual pivots' to extract information from multiple locations (Ripoll & Fleurance, 1988). These visual pivots are thought to highlight the optimal location to anchor the fovea while using the parafovea and periphery to extract information from the display (e.g., Williams & Davids, 1998; Vaeyens, Lenoir, Williams, Mazyn, & Philipparets, 2007). In such situations, a longer QE period may be observed but its duration may be unrelated to motor programming, on-line motor control or the control of arousal. The longer fixation may merely be indicative of the need to extract multiple sources of information from different areas of the display; which highlights the classical differentiation between 'looking' and 'seeing'. We need to better delimit the scope and generalisability of the QE. Our potential to do so is strongly associated with our ability to better understand the mechanisms that contribute to the QE and how these change as a function of the spatial and time-dependent networks involved (Gonzalez et al., 2015a).

What is being trained?

The potential value of QE training has been highlighted (e.g., Causer et al., 2011; Causer, Vickers, Snelgrove, Arsenault, & Harvey, 2014). Yet, not all researchers have embraced the 7-step QE training programme outlined by Vickers (2016). Moreover, the QE training programme proposed in the review article seems more closely aligned with the Decision-Training programme proposed by Vickers in her earlier work (e.g., Vickers, 2007) rather than QE training per se. Moreover, it could be argued that steps 1, 2 and 7 which are outlined in Vickers (2016) are not part of the training programme, but rather are more reflective of the experimental design and methods/measures employed.

In regards to the remaining steps (i.e., 3, 4, 5 and 6), not all papers report using these as part of the training programme (e.g., see Causer et al., 2011). It appears that steps 5 and 6 have not been used by other researchers to train QE. A more typical approach has been to merely use video instruction and feedback to highlight differences between QE periods that are perceived to be more or less optimal. This latter approach has resulted in significant changes in QE characteristics, as well as some transfer from practice to competition, suggesting that only variants of steps 3 and 4 may be crucial in QE training.

We should be cautious in recommending widespread use of QE training programmes. While it is clear that our interventions can change some characteristics of the phenomenon at the behavioural level (e.g., longer duration or earlier onset of QE) our lack of theoretical understanding makes it difficult to determine what is actually being trained at the mechanistic level. How do we know whether any increase in the QE period through training is indicative of enhanced motor programming, a reduction in on-line motor control demands or merely reflective of changes in attention or arousal control? It may be that interventions with different foci are needed to improve each component. In order to be able to fully endorse the benefits of evidence-based practice, we need to better identify the different underlying mechanisms and then develop training programmes that specifically enhance these mechanisms. Clearly, such training programmes not only need to be well-designed, using appropriate control groups and transfer measures, but process tracing measures need to be collected (e.g., fMRI or experimental manipulations employed) to improve understanding of what actually changes as a result of these interventions.

In conclusion, the immense contribution made by Vickers to this area of study is acknowledged. She has identified the phenomenon and provided strong leadership in moving knowledge and understanding forward. However, despite her substantive and exceptionally valuable contribution, much scope remains for further work to improve understanding of what goes on during the QE and how this knowledge may be used to create systematic, evidence-based training programmes.

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Data Availability Statement

All relevant data are within the paper.

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