The Quiet Eye in life and lab – comment on Vickers

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TA COMMENTARY

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ABSTRACT

Inspired by Vicker's (2016) comprehensive review of the quiet eye (QE) in athletics, we review two sets of findings from laboratory studies of typical university students performing visual search tasks. These studies also point to a relationship between longer fixation durations and improved performance, in keeping with the QE in elite athletes. The lab studies also suggest a possible underlying mechanism: longer fixations enable improved predictions of both perceptual and action outcomes. Because these predictions depend on cycles of reentrant visual processing, they benefit from additional processing time. We also caution that under some circumstances longer fixations can be detrimental in visual search, and suggest that this may have analogues in sport.

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visual search – prediction – forward model – reentrant processes – attention

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We confess to some envy of Vickers (2016), for her fortune in discovering the phenomenon of the quiet eye (QE) so early in her career, wisdom in recognizing its importance, and dedication in pursuing it for so many years. Given the QE's ubiquity and consistency in elite sports, one would expect analogous phenomena in other domains. Our laboratory studies of visual searches by typical undergraduates have produced two candidates. Moreover, we speculate that theoretical mechanisms we have proposed to account for our data may contribute to a better understanding of the QE in athletics.

The first set of studies concerned a phenomenon known as the *rapid resumption* of search (Lleras, Rensink, & Enns, 2005). This occurs when participants search for targets among displays that are presented for brief intervals interspersed with blank intervals, simulating what happens when a viewer glances away from a scene and then back again. Targets are detected with extraordinary speed following the reappearance of an interrupted display: only 200 ms, in comparison to 500 ms or longer following the onset of a completely new display. These rapid responses point to a form of memory (of the initial glance at the display) that was reactivated when the expected sensory experience was reinstated. A clear link with fixation duration was apparent: rapid resumption was more common on trials with longer display times (Lleras et al., 2005), and the fixations immediately prior to rapid resumption were longer than those prior to responses made at normal speeds (van Zoest, Lleras, Kingstone, & Enns, 2007).

The second set of studies investigated a *passive advantage* in search (Smilek, Enns, Eastwood, & Merikle, 2006). In these studies, participants were randomly assigned to perform the same search task under either *passive* instructions, which instruct participants to "use your intuition…let the target pop into your mind", or *active* instructions, which tell participants to "be active…deliberately direct your attention." Passively instructed

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searchers were, on average, 20 % faster than actively instructed searchers, and this passive advantage is also tied to fixation duration: passively instructed searchers made longer initial fixations after the search display appears (Watson, Brennan, Kingstone, & Enns, 2010).

Why are longer fixations correlated with better performance on these visual search tasks? We propose that they allow the generation of better predictions for both perception and action, and that this may also explain the advantages associated with the QE in elite athletes. Predictions in the action realm are often referred to as *forward models*: *models* because they involve the construction of mental simulations, and *forward* because they make predictions about future actions, permitting the consequences of these actions to be tested before their execution (Wolpert & Flanagan, 2001). This is critical for overcoming the considerable lag time between physical events and their registration and processing by the nervous system. For example, a simple version of forward modeling prevents our visual experiences from changing radically every time we make a saccade since neuronal activity in the lateral intraparietal area is updated to reflect the expected post-saccadic retinotopic locations of stimuli (cf. Colby, 1998). Better predictions can lead to better action selection, whether the action is the interception of a football or simply a saccade to an optimal location in visual search.

Forward models are not only critical for linking vision to action; they appear to be equally important for perception itself, where what is perceived is often influenced as much by what one is expecting as what is on view (Di Lollo, Enns, & Rensink, 2000; Enns & Lleras, 2008). Following this perspective, we interpret visual search as a series of prediction-comparison cycles. During a fixation, searchers are making predictions about likely target identities and locations, in other words, forward models of the sensory input expected after saccading (or even only covertly attending) to a location. These models are then compared to the actual input received after the saccade (or attention shift). This continues until the input from one fixation is recognized as matching the target, and a motor response is made.

According to this interpretation, the ultra-rapid responses made during an interrupted search indicate that an accurate prediction has already been generated following the first display presentation. During the following presentation, the searcher only has to perform the comparison of the incoming visual information to this already-existing prediction before making a motor response. It seems that this prediction solely concerns the target and its immediate neighborhood, as rapid resumption is eliminated by changing the target location, but unaffected by completely scrambling the location of distractors outside of a small window around the target (Jungé, Brady, & Chun, 2009; Lleras, Rensink, & Enns, 2007).

In a similar vein, the main oculomotor predictor of response speed in our study of the passive advantage was the number of fixations performed *after* the target had been fixated but *before* responding. Passively instructed participants made fewer of these unnecessary fixations, consistent with their having generated a superior prediction of the target's location prior to fixating it, and then being able to more rapidly recognize the target upon fixating it (Watson et al., 2010).

We can also speculate on why longer fixations enable enhanced predictions. According to our predictive account of vision, perception *within* each fixation itself involves a cycle of comparisons that takes place even more rapidly than the *between*-fixation cycle we have just described. At any moment in a fixation, the visual system has generated a representation from the information that was available from the fixation's onset. This is fed back to early visual areas, and compared to the new visual information that continues to arrive, which refines subsequent representations, until the end of the fixation (cf. Di Lollo et al., 2000). Longer fixations may simply enable more reentrant processing cycles, which then contribute to better forward models both in the realms of perception and action.

Finally, we note that a QE may not always be advantageous. Improved predictive capabilities are only useful if these predictions are based on the most relevant information, but in many tasks relevant information lies outside the useful field of view of a single fixation. This entails an inherent trading relationship between longer fixations, which allow enhanced predictions about the information that is currently being fixated, and more frequent saccades, which increase the chances that relevant information will be fixated. Consistent with such a trading relationship, we found substantial overlap in search efficiency between actively and passively instructed groups, with some actively instructed participants having response times that were comparable or even better than some passively instructed participants (Watson et al., 2010). We suggest that these participants were trading the disadvantage of shorter fixations with the advantage of making saccades to more new locations.

In follow up studies, we examined visual search in large-field displays (a real-world messy office, and large photos of this office displayed on a computer screen), and reversed the passive advantage: actively instructed searchers were faster than passively instructed searchers, and made more frequent saccades and head movements to acquire the widely distributed visual information (Brennan, Watson, Kingstone, & Enns, 2011).

Similar active advantages may occur in sports. One study, for example, found that experienced soccer players were superior at anticipating pass destinations while watching a video clips taken from a full 11 on 11 game, and that they made more fixations of shorter duration (Williams, Davids, Burwitz, & Williams, 1994). A previous study using a similar methodology found longer fixations to be advantageous, but this study used set plays such as free kicks, or situations involving far fewer players (Helsen & Pauwels, 1992). We suggest that the QE may be advantageous for tasks that require monitoring relatively few locations that are close to each other, but disadvantageous when multiple task-relevant objects must be monitored over relatively large visual angles, which occurs frequently in team sports.

We close by congratulating Vickers (2016) for a thoroughly enjoyable overview of research on a single variable — the QE —

that has had astonishing longevity and broad impact. We look forward to the continued development of QE theory, both as it applies to sports in real life situations and in the laboratory. We hope our speculations are of interest to others, like us, who want to tie these domains together.

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Competing Interests

The author has declared that no competing interests exist.

Data Availability Statement

All relevant data are within the paper.

References

Brennan, A. A., Watson, M. R., Kingstone, A., & Enns, J. T. (2011). Person perception informs understanding of cognition during visual search. *Attention, Perception, & Psychophysics*, *73*, 1672-1693.

Colby, C. L. (1998). Action-oriented spatial reference frames in cortex. *Neuron*, *20*, 15-24.

Di Lollo, V., Enns, J. T., & Rensink, R. A. (2000). Competition for consciousness among visual events: The psychophysics of reentrant visual processes. *Journal of Experimental Psychology: General*, *129*, 1-27.

Enns, J. T., & Lleras, A. (2008). What's next? New evidence for prediction in human vision. *Trends in Cognitive Sciences*, *12*, 327-333.

Helsen, W., & Pauwels, J. M. (1992). A cognitive approach to visual search in sport. In D. Brogan & K. Carr (Eds.), *Visual search II* (pp. 177-184). London: Taylor and Francis.

Jungé, J. A., Brady, T. F., & Chun, M. M. (2009). The contents of perceptual hypotheses: Evidence from rapid resumption of interrupted visual search. *Attention, Perception, & Psychophysics*, *71*, 681-689.

Lleras, A., Rensink, R. A., & Enns, J. T. (2005). Rapid resumption of interrupted visual search: New insights on the interaction between vision and memory. *Psychological Science*, *16*, 684-688.

Lleras, A., Rensink, R. A., & Enns, J. T. (2007). Consequences of display changes during interrupted visual search: Rapid resumption is target specific. *Perception & Psychophysics*, *69*, 980-993.

Smilek, D., Enns, J. T., Eastwood, J. D., & Merikle, P. M. (2006). Relax! Cognitive strategy influences visual search. *Visual Cognition*, *14*, 543-564.

van Zoest, W., Lleras, A., Kingstone, A., & Enns, J. T. (2007). In sight, out of mind: The role of eye movements in the rapid resumption of visual search. *Perception & Psychophysics*, *69*, 1204-1217.

Vickers, J. N. (2016). Origins and current issues in Quiet Eye research. *Current Issues in Sport Science*, *1:101*. doi: 10.15203/CISS_2016.101

Watson, M. R., Brennan, A. A., Kingstone, A., & Enns, J. T. (2010). Looking versus seeing: Strategies alter eye movements during visual search. *Psychonomic Bulletin and Review*, *17*, 543-549. doi: 10.3758/PBR.17.4.543

Williams, A. M., Davids, K., Burwitz, L., & Williams, J. G. (1994). Visual search strategies in experienced and inexperienced soccer players. *Research Quarterly for Exercise and Sport*, *65*, 127-135.

Wolpert, D. M., & Flanagan, J. R. (2001) Motor prediction. *Current Biology*, *11*, 729-732.