

## Quiet Eye: The efficiency paradox – comment on Vickers

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### TA COMMENTARY

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### Introduction

The publication of Joan Vickers' seminal Quiet Eye (QE) papers (Vickers, 1996a, 1996b, 1996c) offered the promise of a widely generalizable, distinguishing psychomotor metric of expertise. A voluminous body of empirical and applied work has emerged over time, consistently supporting the QE as a reliable covert index of performance excellence (Vickers, 2016). In short, the QE has stood the test of time. Qualitative (Causer, Janelle, Vickers, & Williams, 2012; Wilson, Causer, & Vickers, 2015) and quantitative reviews (Mann, Williams, Ward, & Janelle, 2007) have reiterated the QE as a robust discriminator of expertise and precursor of successful performance. Despite extensive empirical support and widespread perceptual training programs, the underpin-

nings of the QE period remain poorly understood, and in some ways, counterintuitive.

### The efficiency paradox

Perhaps the most robust phenomenon in all performance-related visual search research is the nearly ubiquitous finding that experts and expert performance are consistently characterized by an earlier onset and longer QE. From both scientific and intuitive perspectives, endorsement of a "longer is better" recommendation seems rather crude, and the principal mechanisms associated with this recommendation remain speculative. Simply stated, it seems illogical to expect that a longer is better adage is advantageous across performance situations

### ABSTRACT

The extant literature abounds with evidence in support of the foundational tenets advanced in Vickers' pioneering papers describing the Quiet Eye (QE). Central among her seminal findings is the rather counterintuitive finding that experts and expert performance are characterized by an extended QE period. A longer QE has been oft-replicated across both self-paced and externally-paced tasks, but seems at least superficially inconsistent with broadly accepted notions that increasing levels of expertise are afforded by greater automaticity and efficiency. This "efficiency paradox" is considered in the context of theorized processes that occur during the QE. Answers to questions concerning the mechanisms underlying the extended QE hold great promise for advancing our understanding of the QE specifically, as well as expertise based differences in visual attention more broadly.

#### Keywords:

efficiency paradox – cortical efficiency – motor preparation – attention – emotion

where efficiency is paramount. Research examining the many underlying attributes of expertise has generally concluded that experts are more efficient, effective, and accurate in recognizing task-specific patterns, more proficient at making decisions, maintain superior procedural and declarative information, have a profound reservoir of retrievable contextual cues, and possess an unparalleled ability to foreshadow events and outcomes (Holyoak, 1991, Stakes & Allard, 1993, Mann et al., 2007). If efficiency, strictly speaking, enables experts to perform greater, more detailed work in relation to the total energy expended, how then does the QE represent and/or enable efficiency? Is it simply because the QE acts to reduce the number of fixations and fixation locations during the moments leading up to performance execution? Furthermore, why is a prolonged duration of the QE period necessary for the expert advantage to emerge? We briefly explore this paradox in the context of the literature examining the relationships between QE and cortical efficiency, motor preparation, and emotion regulation.

### Cortical efficiency

From a purely visuomotor perspective, the QE may serve to maximize efficiency, as reflected in cortical patterns indicative of elite performance (Janelle et al. 2000; Janelle & Hatfield, 2008). Research has consistently reported cortical quieting in the left hemisphere as compared to the right (at temporal, mid-frontal, occipital, and parietal regions) when performing visuospatial and motor coordination tasks (e.g., Crews and Landers 1993; Haufler, Spalding, Santa Maria, & Hatfield, 2000; Janelle & Hatfield, 2008). Elite athletes generally make fewer fixations of longer duration, suggesting a level of information processing efficiency that permits more time to be spent on task-relevant cues and less time in search of these cues (Mann et al., 2007). As such, time to movement onset – otherwise said, decision-action time – should be reduced in the expert. A prolonged QE may permit a similar advantage. Task-salient cues are prioritized during visual search, particularly during the final fixation. During this time, cortical resources are likely reallocated away from analytical processing and irrelevant sensory cues and toward the visuospatially dominant perceptuomotor processes that are critical for effective motor programming and execution. Why the efficiency paradox? Neural efficiency refers to the attainment of superior performance along with simultaneous spatial localization or a reduction in brain activity (Costanzo et al., in press). Studies of motor planning in expert golfers have demonstrated that brain activation during the pre-shot routine is radically different from that of less skilled performers (Mann, Coombes, Mousseau, & Janelle, 2011, Milton, Solodkin, Hlustik, & Small, 2007). The expert brain arguably uses less energy to cope with the task demands by converging activation on smaller brain areas and/or less global activation. Irrelevant brain processes are inhibited while essential brain regions exhibit elevated activity as needed, compared to that observed in less-expert performers. Incidentally, a link between cortical

efficiency and the QE duration has been demonstrated (Mann et al., 2011). Although the experts were more proficient, it is unlikely we can argue they were more efficient based on the QE data reported.

### Motor preparation

Conceptually, the QE period is thought to represent the time needed to organize the visual parameters and neural networks responsible for the orienting and control of visual attention (Vickers, 1996a, 1996b). Vickers (1996a, 1996b) has relied heavily on basic cognitive neuropsychological evidence to advance postulates on the cerebral architecture that underlies the QE period. Leveraging the early work of Posner and Raichle (1991), who proposed a three-component network for visual attention, Vickers suggested that the QE period has implications for motor preparation. The orienting network affords shifts in attention, while the executive network works to identify the most salient cues for goal directed behavior, and the vigilance network functions to support focused attention by enabling the orienting system and suppressing the processing of irrelevant stimuli. A secondary effect, therefore, of the vigilance network may be the reorganization of the neural networks responsible for maintaining visuospatial processing and the activation of the appropriate motor program. Preparatory activity in the milieu of sensorimotor alterations involves an integrated neural conduit linking perception to action (Toni & Passingham 2003). The QE appears to functionally represent the time needed to organize the neural networks and visual parameters responsible for the orienting and control of visual attention (Mann et al., 2007; Vickers 1996a, 1996b).

Given this contention, we are again faced with the paradoxical notion that the QE period, a discernible measure of expertise, is consistent with the increased efficiency associated with expert performance. During the preparation and movement phases of skill execution, the visual attention centers (i.e., occipital and parietal cortex) propagate the necessary directives to the motor regions of the cortex (i.e., motor cortex, premotor cortex, supplementary motor area, basal ganglia, and cerebellum). Consequently, the cortical areas responsible for execution of a motor task may in turn benefit from the reallocation of resources during the QE period, allowing for the development of a more refined motor program that results in better performance and greater expertise levels. The question remains, whether the QE period is the cause or the effect of this reorganization, and why such parameterization should not occur more quickly for experts.

### Emotion regulation

A large body of knowledge has emerged lending support to the debilitating effects of anxiety on performance, processing efficiency, and cue utilization. As an extension of this work, several researchers have suggested that the QE period may reflect the regulation of emotional states (Janelle et al., 2000; Mann et

al., 2011; Vickers, Williams, Rodrigues, Hillis, & Coyne, 1999) and the needed reinvestment of greater information processing to sustain performance. That is, the extended QE duration that is characteristic of experts may in fact represent the time needed to accommodate the detrimental effects of anxiety/arousal on the recruitment of task specific resources. Consistent across a variety of reports, the QE duration is influenced by modulations in cognitive stress, physiological arousal, or pressure. Importantly, QE duration has consistently been reported as longer for elite compared to subelite performers across conditions (Causser, Holmes, Smith, & Williams, 2011; Mann et al., 2007; Wilson et al., 2015). The notable differences in QE under adverse conditions and between skill levels supports an emotion regulation function, or a function that is, at minimum, susceptible to emotional reactivity. Apparently, efficiency in emotion regulation, which may indeed occur more quickly, does not speed the QE, but rather permits preservation of the processes that occur during an extended QE period.

## Implications

Considering the collective evidence summarized here, a trend begins to emerge suggesting the QE may be representative of a covert pruning process that requires additional time to align the perceptual cognitive systems with the motor systems to execute a skill at its highest level. Why experts take more time to navigate the processes that are theorized to underlie the QE remains unknown. The “efficiency paradox”, as we have called it, is perplexing. Moving beyond a superficial understanding of what the QE is, and what happens during the QE will require creative research designs, innovative approaches, and mechanistic manipulations. Exploration of remaining questions spurred by Vickers’ seminal work will not only allow a more complete understanding of the QE, but will aid in advancing the knowledge base and training recommendations to facilitate the acquisition and refinement of expert performance across multiple performance domains.

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## Data Availability Statement

All relevant data are within the paper.

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