Quiet eye duration is associated with throwing results in darts, but is it the mechanism?

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Introduction

The phenomenon of quiet eye is a characteristic of expertise (Vickers, 1996). It is defined as the final fixation or tracking gaze located on a specific location or object in the visuomotor workspace within 3° of visual angle for a minimum of 100ms. Moreover, the onset of the quiet-eye occurs prior to the final movement in the task and the offset occurs when the gaze deviates off the object or location by more than 3° of visual angle for a minimum off 100ms; therefore, the quiet-eye can carry through and beyond the final movement of the task (Vickers, 2009). The quiet eye duration has been associated with expertise and superior performance in a range of tasks (e.g. McPherson & Vickers, 2004; Vickers, Rodrigues, & Edworthy, 2000; Vickers & Williams, 2007). First, experts seem to have longer quiet eye duration and an earlier onset of the last fixation concerning the initiation of the motor response. Second, the association of quiet eye duration and throwing performance shows longer durations for hits in comparison to misses. Against the background of an effective quiet eye control by experts, the phenomenon is seen as a key factor of optimal perceptual motor coordination (Vickers, 2007; Williams, Singer, & Frehlich, 2002).

Different approaches exist to explain the phenomenon of quiet eye, but interestingly yet the mechanism behind this relationship seems to be unsettled (Vine, Moore, & Wilson, 2011). Vickers (2009) suggests the quiet-eye period contains the time of processing the fixated information. It remains unclear, if by ‘fixation’ is meant the foveal information processing, or if ‘fixation’ is inclusive of the whole field of vision? Aim of this study was to investigate whether the information pick-up of fixated information is the underlying mechanism of the quiet eye.Therefore we first try to replicate the findings concerning the quite eye. Furthermore we investigate the influence of isolated foveal and peripheral information pick-up concerning the throwing performance.

Methods

This issue has been investigated using a *contingent change display paradigm* (Abernethy, 1988; McConkie & Rayner, 1975), which involves changing the visual display in accordance to the participants‘ eye-movements. The field of vision moves parallel to the executed fixations, enabling an experimental control of the given information. This allows the control of foveal vision while limiting coincident peripheral vision and the inverted way and enables to investigate whether foveal and peripheral information pick-up and processing lead to different results. Skilled (n = 13) and less skilled (n = 16) dart players were investigated concerning their dart throwing performance and gaze behavior. All were right-handed male subjects. The mean age of the skilled and less-skilled groups were 36.6

(*SD* = 10.5) and 25.5 (*SD* = 1.3) years respectively. The skilled players were members of the local dart league with an average of 11.7 (*SD* = 6.5) years of playing experience, and the less-skilled counterparts had occasional experience with dart throwing (< once a month). The task included a total of 45 dart shots, subdivided into one block (baseline condition) plus two blocks (foveal and peripheral vision). These two blocks with occluded vision were presented counterbalanced. Every block included 15 trials.

Results

Throwing results shows significant differences between skill groups in baseline condition, $t(27) = 5.29$, $p < .01$, $d = 2.00$ (cf. Figure 1). Analysis of variance with a between-subject factor (groups) and a repeated measurement factor (foveal vs. peripheral) only shows significant differences in throwing accuracy between groups, $F(1,27) = 26.87$, $p < .01$, $\mu^2_p = .50$. Neither visual occlusion conditions, $F(1,27) = 2.14$, $p = .15$, $\mu^2_p = .07$, $1 - \beta > .99$, nor their interaction, $Fs(1,27) = 1.71$, $p = .20$, $\mu^2_p = .06$, $1 - \beta > .99$, were significant. For quiet-eye duration during baseline performance, the difference between skilled and less-skilled groups approached significance, $t(27) = 1.42$, $p = .08$, $d = .52$,1 - ß = .39 (cf. Figure 1). The analysis of variance with repeated measures revealed neither significant group differences, $F(1,27) = 0.09$, $p = .75$, $\mu^2_p < .01$, $1 - \beta = .07$, nor differences between visual conditions, $F(1,27) = 0.58$, $p = .45$, $\mu^2_p = .02$, $1 - \beta = .31$, nor their interaction, $Fs(1,27) = 0.32$, $p = .57$, $\mu^2_p = .01$, $1 - \beta = .20$.

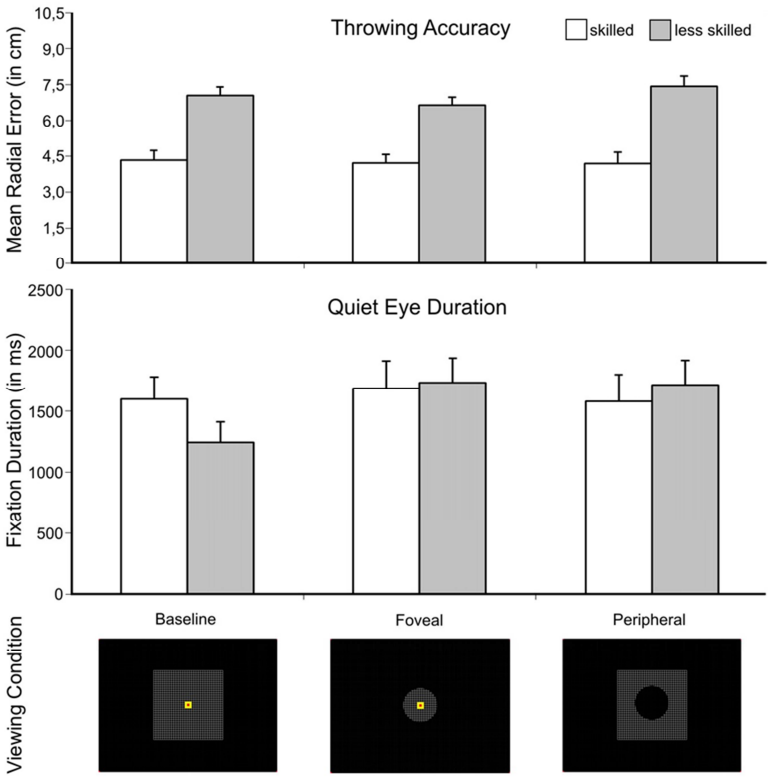

Figure 1: Throwing results, presented as throwing accuracy and eye-movement behavior, presented as quiet-eye duration of skilled ($n = 13$) and less-skilled ($n = 16$) dart players for different viewing conditions (baseline, foveal, and peripheral vision).

Discussion

Aim of the investigation was the replication of quiet eye as well as examining the underlying mechanism of the phenomenon of quiet eye. First we could replicate quiet eye and throwing performance. The skilled dart players outperformed the less skilled players significantly and showed longer quiet eye durations, which only approaches significance. Second the check of information pick-up as quiet eye mechanism shows no influence of occluded viewing condition, neither on throwing accuracy nor on quiet eye period for skilled players. But is seems as if the less skilled players‘ quiet eye duration is influenceable by foveal and peripheral vision condition. They show enlarged quiet eye duration without an improvement in throwing performance. Suggesting the foveal information pick-up is the deciding underlying mechanism of quiet eye could not be confirmed by the current issue. First a shift of vision condition does not influence the throwing accuracy and second the less skilled players' throwing behavior shows no improvement despite an enlarged quiet eye period.

Conclusions

These results lead two more research questions. First a replication of the current study with two modifications could be useful. Maybe the level of expertise was not high enough to find significant quiet eye differences, so a replication with experts should be considered. Furthermore an additional *no frame* condition is necessary to ensure that foveal vision condition is not only perceived as enlarged target. Concerning the mechanism of quiet eye further research need to be done to understand *how* and *why* this phenomenon of perceptual expertise works.

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