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The Effects of a Visual Distraction on Quiet Eye Duration and Putting Performance of Collegiate Golfers

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The purpose of this study was to evaluate the effects of a visual distraction on Quiet Eye duration and putting performance during low and high pressure situations. Eight Division-I collegiate golfers completed 50-putts in a low and 50-putts in a high pressure condition. A camera flash was used to distract players during the execution of the Quiet Eye. A significant and moderately strong association between Quiet Eye duration and putting performance was found. Quiet Eye was significantly longer during trials with visual distractions compared with trials with no visual distractions. The performance of participants did not differ significantly in the visual distraction compared with the no visual distraction condition. It is possible that athletes may use a longer Quiet Eye period as a coping mechanism to help them overcome the distraction and maintain the same level of motor performance.

Keywords: golf, quiet eye, distractions

A golfer is required to use many different clubs during a round of golf. Although it is important to use all clubs effectively, skilled use of the putter has been shown to be a significant determinant of performance and earnings among PGA golfers (Alexander & Kern, 2005). Therefore, understanding the factors that affect putting performance is critical. Previous research has indicated that one of these factors is gaze behavior. In fact, a long eye fixation on the ball, starting before the putting action begins and ending after follow-through, has been shown to correlate to an increase in golf putting performance (Vickers, 1992). This final fixation is known as the Quiet Eye (QE). The QE has been demonstrated to be a valid determinant of performance in several different sports such as golf (Moore, Vine, Cooke, Ring, & Wilson, 2012; Vickers, 1992), volleyball (Vickers & Adolphe, 1997), soccer (Wood & Wilson, 2011), hockey (Martell & Vickers, 2004; Panchuk & Vickers, 2006), and rifle shooting (Janelle et al., 2000). In golf, expert putters have a quiet eye of approximately 2 seconds (Vickers, 1992). It seems that the QE is a time period

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necessary for the brain to effectively plan an action in order for consistent high levels of performance to occur (Williams, Singer, & Frehlich, 2002).

In many sports, unpredictable distractions encountered in competitive environments may negatively affect the appropriate execution of the QE. For example, a sudden movement or a camera flash may distract a golfer during the performance of a putt. Although visual distractions have been studied in relation to everyday tasks such as automobile driving, research on visual distractions in sports is limited to a single study (Wood & Wilson, 2010). This study examined the effects of distractions of a moving goalkeeper on the gaze behavior and performance of penalty kickers in soccer. It was determined that penalty kickers tended to look more often and for a longer period of time at the goalkeeper when he was moving compared with when he was stationary. The movement of the goalkeeper distracted penalty kickers, which led to a decrease in penalty kicking performance. Even though moving from side to side is a strategy commonly employed by soccer goalkeepers, it nonetheless remains an effective mechanism to distract penalty kickers.

Sports such as golf specifically attempt to limit external distractions during competitions. Examples include prohibiting flash photography during golfers' swings and "Quiet, Please" signs aimed to silence fans in the gallery. While fairly effective, there are occasions during which these rules are broken and distractions of flash photography occur. Many golfers are visibly frustrated when this happens. This frustration can be amplified during high pressure situations such as important competitions or close scoring matches. In fact, research has consistently demonstrated that higher levels of anxiety lead to lower QE duration and performance (Causer, Holmes, Smith, & Williams, 2011; Wilson, Vine, & Wood, 2009; Wilson, Wood, & Vine, 2009). Currently, it is unknown if, and how, visual distractions affect golfers' gaze behaviors and putting performance. Therefore, the purpose of the current study was to evaluate the effects of a visual distraction on QE duration and putting performance during low and high pressure situations. It was hypothesized that a visual distraction such as a camera flash would disturb the QE and negatively impact performance. In addition, it was hypothesized that during the high pressure condition, distractions would have a greater impact on gaze behavior and putting performance.

Methods

Participants

Twenty undergraduate students who were members of a golf team at a Midwestern NCAA Division 1 university participated in the study ($N_{male} = 13$, $N_{female} = 7$; $M_{age} = 19.75$; $SD = 1.17$). Of the 20 subjects who completed the study, 12 were excluded in data analysis. Nine of the golfers were excluded after not meeting the predetermined condition of using a quiet eye (i.e., a final fixation on the ball before the stroke lasting at least 100ms for at least 50% of the trials). Three others were excluded because the distractions did not occur during the quiet eye period. Of the eight participants used for data analysis ($M_{male\text{-}age} = 20$, $SD_{male} = 1.63$, $N = 4$; $M_{female\text{-}age} = 19.5$, $SD_{female} = 1.29$, $N = 4$), seven were right handed and one was left handed. Before data collection, the project was approved by the University's Institutional Review Board and informed consent was obtained from all participants.

Instrumentation

Putting Green. The participants performed a golf putting task in a laboratory. All participants used the same style right or left-handed 45 inch putter provided by the researcher, which was similar to what they normally use, to hit a standard golf ball on an artificial green turf toward a target five meters away. The target consisted of five concentric circles. The first circle was the size of a standard golf cup (4.25 inch diameter). Each subsequent circle increased by 20 cm in diameter. A score was assigned to each area, with values decreasing by one point moving from the center cup circle (5 points) to the outermost circle (1 point). The area beyond the outermost circle was given a score of zero.

Gaze and Kinetic Behaviors. The Applied Science Laboratories Mobile Eye Tracker was used to determine gaze behavior. The eye tracker device consists of two cameras mounted to a pair of glasses. One camera uses monocular corneal reflection and pupil position to measure eye-gaze behavior while a second camera records the external environment. The system was calibrated before testing began and after each set of 10 putts. Participants were videotaped with an external camera (Canon ZR900 Mini) to capture putting movements. The Vision-in-Action software system was used to synchronize the eye tracker video with the kinematic movement video (Quiet Eye Solutions Inc.).

Distraction. A camera flash (Godox CF-18 Digital Slave Flash) was used to provide the visual distractions. It was positioned two meters behind the putt line and one meter above the ground.

Anxiety. The Mental Readiness Form-3 (MRF-3) was used to measure competitive state anxiety of the participants (Krane, 1994). The MRF-3 measures cognitive anxiety, somatic anxiety, and self-confidence using three 11-point Likert scales. The cognitive anxiety scale ranges from not worried (1) to worried (11), the somatic anxiety scale ranges from not tense (1) to tense (11), and the self-confidence scale ranges from not confident (1) to confident (11).

Procedures

Participants were tested individually. Upon entering the laboratory each participant provided written informed consent. Participants were fitted with the Mobile Eye Tracker and it was calibrated. The calibration process involved having the participants focus on various points within a 15 point grid placed near their feet. While they were focusing on a single point, the location of the point was entered into the eye tracking software. To deceive participants regarding the camera flash distractions, they were informed that photographs would be taken to assess the mechanics of their swing. The scoring system used to determine the accuracy of putts was explained and they were asked to perform 10 warm-up putts.

After the warm-up, participants were given instructions related to the pressure condition in which they would be performing. Pressure conditions were counterbalanced by participants, with 50 putts being performed in a low pressure condition and 50 putts being performed in a high pressure condition. In the low pressure condition, participants were instructed to attempt 50 putts while their scores were being recorded. In the high pressure condition, participants were additionally read aloud the same three predetermined statements: (a) *Your accuracy and visual behavior results will be compared with your teammates and reported to your coach*; (b) *If your performance falls within the bottom 5% compared with your teammates, your data will not be used in the study;* (c) *As requested by your coach, the five best and five worst performances will be presented to you and your teammates as examples of "Do's and Don'ts in Putting"*. In total, participants performed two sets of 50 putts in blocks of 10 putts. After each block of 10, the participants answered the MRF-3 questionnaire and the eye tracker calibration was checked. If the participants were in the high pressure condition, one of the three statements was repeated at this time.

To determine the effects of distractions on the QE and putting performance, a flash of light originating from a camera flash was used (Godox CF-18 Digital Slave Flash). The camera flash was manually controlled to occur within the Quiet Eye (QE). Distractions were randomly assigned to trials with the condition that 1 distraction occurred every 5 putts. Distractions happened at the same trial across participants and pressure conditions.

For this study, QE was operationally defined using the same parameters as Moore et al. (2012). Specifically, QE was defined as the final fixation on the ball, beginning before the initial putting movement and ending when the fixation moved away from the initial location for more than 100ms (Moore et al., 2012). Thus, participants who did not have the final fixation on the ball lasting at least 100ms and starting before the stroke or those who did not display a consistent QE pattern were removed from the analyses.

After completing the 100 putts, each participant was debriefed. They were informed that the camera flashes were occurring because the purpose of the study was to determine the effect of a visual distraction on putting performance, and the three statements to increase anxiety were false and would not be carried out. Lastly, they were told not to inform their teammates of the conditions of the study.

Statistical Analyses

Descriptive statistics (M, *SD*) were computed for anxiety scores, QE duration, and putting performance. To assess whether participants perceived the high pressure condition as more threatening, the dependent variables MRF-3 scores and overall putting performance were compared between low and high pressure conditions using dependent *t* tests. Due to the lack of significant differences between low and high pressure conditions, data were aggregated for all subsequent analyses. To investigate the association between QE duration and putting performance, a one-tailed Pearson correlation was conducted. The one-tailed test was deemed appropriate considering the overwhelming evidence suggesting that longer QE duration is associated with higher levels of motor performance (Janelle et al., 2000; Martell & Vickers, 2004; Moore et al., 2012; Panchuk & Vickers, 2006; Vickers & Adolphe, 1997; Wood & Wilson, 2011). Experimental manipulations were analyzed using dependent *t* tests. For experimental manipulations, the independent variable was the availability of a visual distraction (20 Flash trials vs. 20 No flash trials) and the dependent variables were QE duration and putting performance. Significance was set at $p < .05$. Cohen's d effect size and observed power ($1—\beta$) were computed for significant results. All statistical analyses were conducted using SPSS 16.0 (SPSS, Inc., Chicago, IL, USA).

Results

Manipulation of Pressure Check

Differences between low and high pressure conditions were not significant for any of the MRF-3 subscales (i.e., worry, tense, and confidence; $p > .05$; Table 1). Overall putting performance during the high pressure condition was also not significantly different from the low pressure condition ($p > .05$).

Association Between QE Duration and Putting Performance

One-tailed Pearson correlation revealed a significant and moderately strong association between QE duration and putting performance ($r = .48$, $p = .03$). As QE duration increased, so did putting performance.

Experimental Manipulations

QE Duration. QE was significantly longer during trials with visual distractions compared with trials with no visual distractions ($t_7 = -4.09$, $p = .005$, $d = .49$, $1—\beta = .94$, Table 2).

Putting Performance. Participants did not differ significantly in performance during trials with visual distraction compared with trials with no visual distraction ($t_7 = -.07$, $p = .51$).

Table 1 Descriptive Statistics for Low and High Pressure Conditions

	Low Pressure		High Pressure	
	M	***SD***	**M**	***SD***
MRF-3				
Tense	2.5	1.85	3.08	1.38
Worry	3.4	2.4	4.2	2.44
Confidence	7.65	2.57	7.3	2.42
Putting performance	3.06	.60	3.17	.58

Table 2 Descriptive Statistics for Visual vs. No Visual Distraction Conditions

	Visual distraction		No visual distraction	
	M	***SD***	**M**	***SD***
QE duration*	1,789	630	1,458	711
Putting performance	3.05	.87	3.24	.50

Note. QE duration is given in milliseconds

*p < .05

Discussion

Within the competitive setting of most sports, unpredictable distractions commonly occur and can negatively affect an athlete's performance. To our knowledge, research on visual distractions in sports is limited to a single study dealing with soccer (Wood & Wilson, 2010). There are many diverse sporting environments (open/closed, team/individual, indoor/outdoor, etc.) as well as various characteristics needed for successful performance in each specific sport. It is unclear if the results of the existing soccer study would be similar when applied to sports such as golf. Therefore, the objective of the current study was to evaluate the effects of a visual distraction on QE duration and golf putting performance during low and high pressure situations.

The QE period has been suggested as the time needed by the brain to plan the action necessary for successful execution of a task (Williams et al., 2002). The results of this research provide additional support for this premise. Successful execution of longer QE behaviors during golf putting was associated with more successful putting performance. While longer QE behaviors resulted in better performance, it should be noted that QE duration for high (1,789ms) and low (1,458ms) pressure conditions for the collegiate golfers participating in this study were shorter than the 2 seconds displayed by expert golf putters (Vickers, 1992). It may be that even longer QE durations would have positively influenced putting performance. Therefore, it is strongly recommended that QE training be implemented into golf putting practices.

In addition, the ability to successfully execute the task should diminish if a distraction occurs during the QE and interrupts the action planning. Contrary to our hypothesis, a distraction did not negatively affect putting performance in the current study. No significant difference between distraction and nondistraction trials was found. These results also contradict those of Wood and Wilson (2010), who found that visual distractions decreased performance of penalty kicking in soccer. One possible explanation for the dissimilar results is the methodological differences between the two studies. Although both studies were conducted in laboratory conditions, the current study used only one distraction, a finite camera flash, whereas Wood and Wilson (2010) used a moving goalie, which provided more of a continuous and ongoing distraction. The timing of the distractions was also different. The distraction in the current study occurred during the quiet eye period, while the distraction used in Wood and Wilson (2010) started before quiet eye behaviors were set. The combination of the ongoing distractions with the time of their occurrence may have had a larger impact on the kickers' ability to perform than that of the camera flash on the golfers' putting performance.

Another plausible explanation is that athletes may have used a longer QE period as a coping mechanism to help them overcome the distraction. Results from the current study found that athletes had significantly longer QE periods during trials in which a visual distraction occurred. Thus, it seems that the camera flash distraction did not have a negative effect on golfers. Instead of decreasing QE, perhaps golfers used a longer QE to overcome the distraction and perform as well as they would have without the distraction. It has been previously suggested that athletes, when confronted with difficult situations such as high pressure/anxiety, use a variety of strategies to cope with these situations (Balk, Adriaanse, de Ridder, &

Evers, 2013; Gaudreau, Nicholls, & Levy, 2010; Sagar, Lavallee, & Spray, 2009). Although further investigation is needed, lengthening the QE may be a mechanism used to overcome environmental stresses.

It was also hypothesized that during the high pressure condition, distractions would have a greater impact on gaze behavior and putting performance. Previous studies have found that increases in pressure tend to negatively impact the QE period, and consequently, performance (Causer et al., 2011; Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009). While a pressure manipulation was attempted and the scores were in the predicted direction, the results did not show any significant differences in MRF scores or putting performance between high and low pressure conditions. Therefore, it was not possible to assess whether distractions would have differing effects on conditions with different levels of pressure.

Limitations

There were a number of limitations in the current study. Although the pressure manipulation used was very similar to other studies (Causer et al., 2011; Moore et al., 2012; Vine & Wilson, 2011; Wilson et al., 2009), it was ultimately unsuccessful. It is possible the manipulations were not close enough to the characteristics of an actual high pressure competition environment to which the collegiate athletes participating in this study are accustomed, or perhaps the anxiety assessment was not sensitive to subtle changes in anxiety since it was repeated only after every block of 10 putts. Another explanation is that the putting task was too easy (completely level surface, relatively short distance, continuous execution of the exact same putt) to elicit a change in anxiety levels. Because the participants regularly compete on more difficult putting greens, the putts they were asked to perform in the experiment may not have been as demanding. Next, the sample size could have been larger. Lastly, distractions were only assessed during the QE period and not before or after it. Future studies should attempt to create a more realistic competition environment, in terms of the anxiety levels experienced as well as the technical difficulty of the putt itself. They should also attempt to assess distractions that occur at other times during a putt, outside of just the QE period.

Application

To improve or maintain high levels of motor performance, we strongly suggest the implementation of QE training in golf practices. As in past studies (Moore et al., 2012; Vickers, 1992), QE behaviors were positively associated with golf putting performance. Training the QE has been shown not only to significantly improve motor skill performance (Adolphe, Vickers, & Laplante, 1997; Vine & Wilson, 2011; Wood & Wilson, 2010, 2011), but also to protect motor performance against high levels of anxiety (Moore et al., 2012; Vine & Wilson, 2011). In addition, this study demonstrated that the elongation of the QE period seemed to shield putting performance from the camera flash distractions.

Conclusion

This study demonstrated the benefits of a successful execution of QE behaviors during golf putting. Longer QE periods were associated with more successful putting performance. Although anxiety may have a negative impact on QE and performance (Causer et al., 2011; Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009), previous research has also demonstrated that training the QE may work as a buffer against the deleterious effects of anxiety on performance (Moore et al., 2012; Vine & Wilson, 2011). This study specifically demonstrated an additional benefit to performing successful QE behaviors. Likely due to an elongation of the QE period, camera flash distractions did not affect putting performance. Elongation of the QE period may also be further evidence that the QE period is essential to the planning of certain motor actions (Williams et al., 2002). It is possible that similar levels of putting performance in trials with and without distractions were a result of more time provided to the brain to plan the putting action when distractions occurred.

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