Journal of Sports Sciences, 2011; 1–9, i*First* article

Visually focusing on the far versus the near target during the putting stroke

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(Accepted 23 May 2011)

Abstract

The purpose was to evaluate the traditional method, of visually focusing on the ball, in comparison to focusing on the hole, during the putting stroke. The study design consisted of a pretest, a 4-week practice period, and a posttest. Participants ($n = 31$, handicap: 18.7 ± 10.4) practised using only one of the two gaze techniques. Testing consisted of having all participants putt using both gaze techniques from both a 1.22 m and a 4 m distance. Five putts were executed for each gaze technique/putt length combination for a total of 20 putts in each testing session per participant. The kinematics of every putting stroke executed during testing (1240 strokes) were captured using a TOMI® system. There was a significant improvement in putting success for both groups following practice ($P = 0.001$). Practising while visually focusing on the hole, resulted in a statistically significant reduction in putter speed variability in comparison to practising while visually focusing on the ball ($P = 0.017$). Visually focusing on the hole did not meaningfully (nor statistically) affect the quality of impact as assessed by the variability in face angle, stroke path, and impact spot at the precise moment the putter head contacted the ball.

Keywords: *Golf, putting, visual focus, kinematics, technique*

Introduction

Putting is an essential skill in the game of golf. According to the Professional Golf Association (PGA) Tour statistics, the putting stroke accounted for 39.5 % of all strokes made during tournament rounds of golf in 2009 (PGA Tour, 2010a; PGA Tour, 2010b). Perhaps due to its relative importance, or apparent simplicity, more variations in technique have been evidenced in putting than any other shot type in golf. Modifications in stance, stroke, club design, and grip have contributed to the variations in putting technique. However, regardless of the variation, the golfer's target of visual focus during the actual putting stroke remains the same. Throughout the stroke, golfers are instructed to focus on the ball (near target) (Ruthenberg, 1992; Saunders, 1997); yet, the ball conveys no important information about the desired direction or speed of the putt. The far target (e.g., the hole on straight putts), and the section of the green the ball must traverse, determine the optimal speed and direction that should be imparted to the ball.

The use of vision while putting can be compared to skills such as free-throw shooting in basketball in that the goal is to project an implement (e.g., ball) at a far target (e.g., hole/hoop). In free-throw shooting, there seems to be an advantage in visually focusing on the far target *immediately before* the body movements which lead to the projection of the ball (Vickers, 1996a, 1996b, 1996c). Visually focusing on the far target allows the performer to better estimate the correct amount of impulse to apply to the ball (Vickers, 1996c; Williams, Singer, & Frehlich, 2002). This final visual fixation on the target has been termed the 'quiet eye period' and has been reported as being a key to success in other sports such as dart throwing and billiards (Vickers, Rodriguez, & Edworthy, 2000; Williams et al., 2002). However, unlike basketball in which the ball is pushed from the hands, putting requires the ball to be accurately *struck* in order to propel it to the far target. If the golf ball (near target) could be struck with sufficient accuracy, while focusing on the far target, then the golfer could presumably take advantage of the type, and timing, of visual information that seems critical in skills such as

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ISSN 0264-0414 print/ISSN 1466-447X online © 2011 Taylor & Francis
DOI: 10.1080/02640414.2011.591418

free-throw shooting and dart throwing (Vickers, 1996a; Vickers et al., 2000). Since the majority of the putting instruction literature suggests focusing on the ball during the stroke, it can be inferred that the current paradigm of putting technique is based on the assumption that not focusing on the ball will result in a poor quality of strike.

With respect to vision, billiards is particularly similar to putting in that both skills involve near and far aiming components. Williams et al. (2002) investigated the location and duration of visual focus during four phases of a billiards shot. Skilled and unskilled performers executed shots representing three levels of complexity: easy, intermediate, and hard. For the easy condition, longer fixations were directed at the object ball (a far target) in comparison to the cue ball (near target). It was also reported that skilled performers fixated on the target ball (a far target) for a significantly longer duration in comparison to less skilled players. For the intermediate condition, players fixated longer on the cushion (a far target) than on the cue ball (near target). It was only in the hard condition that fixation was longer on the cue ball in comparison to the far targets individually; however, collectively, performers fixated longer on the far targets than on the cue ball. Although the quiet eye period was found to be significantly longer for skilled performers, results were not reported regarding which location was specifically fixated on during either the quiet eye period, or movement phase.

Vickers (1992), while researching gaze control in near target-oriented putting, concluded that visually focusing on the ball for an extended period of time, *during the stroke*, resulted in improved accuracy. In contrast, more recent research has shown that even when golfers putt with their visual focus in the area of the near target (ball), it may not be advantageous to focus directly on the ball. Naito, Kato, and Fukuda (2004) found that beginners tended to focus solely on the ball during the stroke, unlike professional golfers who focused at points either slightly before or slightly after the ball. This is anecdotally supported by two accomplished golfers from the PGA Tour. Tom Watson (leading the Champions Tour in putting average as of July 11, 2010) has suggested watching the hands during the stroke on short putts to smooth out the stroke and prevent steering the ball into the hole (Watson, 2007), while Loren Roberts (#1 in putting average on the PGA Tour in 1994) suggests letting the eyes fall out of focus to make the stroke softer and smoother (Miller & Yocom, 2001).

While most research has focused solely on the traditional, near target-oriented putting technique, some research studies have compared the traditional method to a far target-oriented approach. Using non-golfers, Bowen (1968) had one group putt while focusing on the ball, and a second group putt while focusing on the hole. Bowen found no differences, between the two methods, in either distance or direction errors. Cockerill (1979) conducted a similar study but modified the design to investigate the interaction of skill level (<6 handicap vs. non-golfer) with the location of visual focus during the stroke (ball vs. hole). Both groups were tested using both techniques, without practice, along a straight and flat platform. There was no significant interaction and, as with Bowen, there were no significant differences between the two techniques in either distance or direction errors. Aksamit and Husak (1983) extended Bowen's study design by incorporating a third "no-vision" group, which was blindfolded just prior to the initiation of the putting stroke. Without practice, each group putted using only one of the three vision conditions. Again, there were no significant differences in either direction or distance errors between visual conditions. Gott and McGown (1988) investigated two vision conditions (ball vs. hole) as well as two methods of stance (conventional vs. side-saddle) using a group of non-golfers. No differences were found in either the final resting location of the ball relative to the hole, or the number of successful putts. Collectively, these four studies suggest that the target of visual focus has no net effect on putting success. In a recent pretest/posttest study, 40 golfers were divided into two vision groups (ball vs. hole) (Alpenfels, Christina, & Heath, 2008). Following 45 practice putts, the group that looked at the hole putted significantly closer to the hole (24%) on a series of posttest putts between 28 and 43 ft (8.5 and 13 m) in length; they also improved nearly twice as much as the traditional putting group from that distance. Those who looked at the hole also performed better on putts between 3 and 8 ft (0.9 and 2.4 m) in length.

Of note, the five aforementioned putting studies were limited by their choice of dependent variable, final resting location of the ball, to investigate the influence of visual focus on the putting stroke. Measuring the actual putter kinematics, which primarily determine the final resting location of the ball, is important for two reasons. First, the putter head kinematics at impact provide a more discerning evaluation of the error committed by the golfer. For example, in the aforementioned studies that investigated gaze location, a putt that stops short of the hole may be attributed to insufficient putter speed, where in fact, it could be solely the result of a mishit. Second, it is probable that the two techniques may not affect each subskill of the putting stroke in the same way. Previous research suggests that focusing on the ball should result in a higher quality of impact (Abrams, Meyer, & Kornblum, 1990; Vickers, 1992), while focusing on the hole may result in a better estimation of the correct putter speed with which to impact the ball (Laabs, 1973; Vickers, 1996c; Williams et al., 2002). A specific set of four kinematic variables, under the control of the golfer, can be identified as the main deterministic factors in the outcome of a putt (MacKenzie & Evans, 2010). Three of these variables, face angle, stroke path, and impact spot, characterise the quality of the impact, while the fourth, putter speed, indicates the golfer's ability to correctly estimate the required impulse.

The purpose of this study was to evaluate the traditional method, of visually focusing on the ball, in comparison to focusing on the far target, such as the hole on a straight putt, following a series of practice sessions. It was hypothesised that focusing on the far target may lead to an improvement in the consistency of the speed with which putts are struck; however, it may also result in a reduced quality of impact (face angle, stroke path, and impact spot) with the ball.

Methods

Participants

Thirty-one male golfers (age: 22.3 ± 4.1 years, handicap: 18.7 ± 10.4, 11 left handed and 20 right handed) volunteered to participate. The study was approved by the University's Research Ethics Board, and testing procedures, risks, and time required were fully explained to each participant before they read and signed an informed consent document. All participants entered the study having only used the traditional putting technique, which is characterised by visually focusing on the ball during the stroke.

Study design

The study design consisted of a pretest data collection, a practice period, and a posttest data collection. Participants practised using only one of the two gaze techniques. Testing consisted of having all participants putt using both gaze techniques from both a 1.22 m and a 4 m distance. These distances coincide with previous research (Gott & McGown, 1988) and allow the visual techniques to be compared on a short putt, with a high probability of success, and a longer putt, with a low probability of success. Five putts were executed for each gaze technique/putt length combination for a total of 20 putts in each testing session per participant. The order of each set of five putts was randomised in each testing session. At the start of each testing session, 10 practice putts were performed from each distance, alternating between the two gaze techniques. This study design was employed to test the effect of the four independent variables: test (pre, post), distance (1.22 m, 4 m), practice group (near, far), and gaze technique (near, far). The independent variables test, distance, and gaze technique are considered within-subjects factors (repeated measures), while practice group is considered a between-subjects factor. The effect of the independent variables was assessed through the measurement of four primary dependent variables: face angle, stroke path, impact spot, and putter speed as well as the number of successful putts.

Operational definitions

In order to operationally define the four dependent variables, an inertial frame of reference is useful. The positive X-axis extends from the centre of the putter face along the intended initial direction of the putt and is coincident with the target line. The positive Y-axis extends vertically up from the ground and the positive Z-axis is formed according to the right-hand-rule (Figure 1a). Face angle is defined as the angle formed between the target line and a line which is perpendicular to the putter face (Figure 1b). Stroke path is defined as the angle between the velocity vector of the putter head and the target line (Figure 1c). Putter speed is defined as the velocity of the centre of the putter face along the X-axis (target line). Impact spot is defined as the distance from the centre of the putter face to the ball contact point, along the heel-toe axis of the putter. All four variables are measured at impact. The origin of the reference frame is a theoretical position located at the centre of the putter face when the centre of the putter face is contacting the ball and both face angle and impact spot are zero.

Data collection and processing

All putts were executed with Nike Unitized Retro putters, 0.89 m (35'') in length, on a synthetic putting surface that was 7 m long and 5 m wide. The surface was nominally flat and had a Stimp reading of 3.5 m ($\sim$11.5 ft). Stimp is the standard measurement of green 'speed' and can be determined by measuring how far a ball rolls when imparted with an initial speed of $1.83 \text{ m} \cdot \text{s}^{-1}$ (6 ft/s). Each ball (Callaway TOUR*i*) was marked with a straight line for aiming purposes. A laser projected a beam that bisected the ball, extended along the aim line, and bisected the hole at the end of the putting surface. Prior to each putt, a researcher placed the ball in the correct location with the marked aim line on the ball directly coinciding with the line projected by the laser. The laser was removed prior to each putt. The ball was marked with an aim line since many golfers use this information during competition. All participants were provided with a marked ball to improve internal validity. If the participants aligned their own balls on each putt, then their ability to correctly orient the aim line on the ball as well as their ability to correctly contact the ball would be measured. While providing all participants with a correctly oriented aim line improved internal validity, it does affect the generalisability of the results. The kinematics of every putting stroke executed during testing (1240 strokes) were captured using a TOMI® system. The TOMI® system consists of a battery charged clip, comprising four light emitting diodes (LEDs), which attaches directly to the putter shaft (Figure 2). A nearby camera receives information from the LEDs about their coordinates in 3D space and relays it to a computer.

A customised program, written in Matlab (R2007a, The Mathworks, Inc., Natick, MA) filtered, upsampled, and transformed the raw data into the necessary form for calculating face angle, stroke path, putter speed, and impact spot. The data were filtered with a fourth order zero-lag low-pass Butterworth filter at a cut-off frequency of 8 Hz, and upsampled to obtain LED coordinates every 0.001 s, which allowed for the precise measurement of each variable at impact. These data collection and analysis procedures have been found to be both valid and reliable (MacKenzie & Evans, 2010).

Each participant executed five putts for each combination of the independent variables, which allowed means and standard deviations for each dependent variable to be determined. The variability in the dependent measures which characterise the quality of impact is more indicative of putting ability than the mean or absolute scores. For example, a consistent 'error' in face angle could be repeatedly cancelled out by an opposing 'error' in stroke path resulting in a successful putting stroke. With putter speed, however, both the mean and standard deviation can be directly indicative of putting

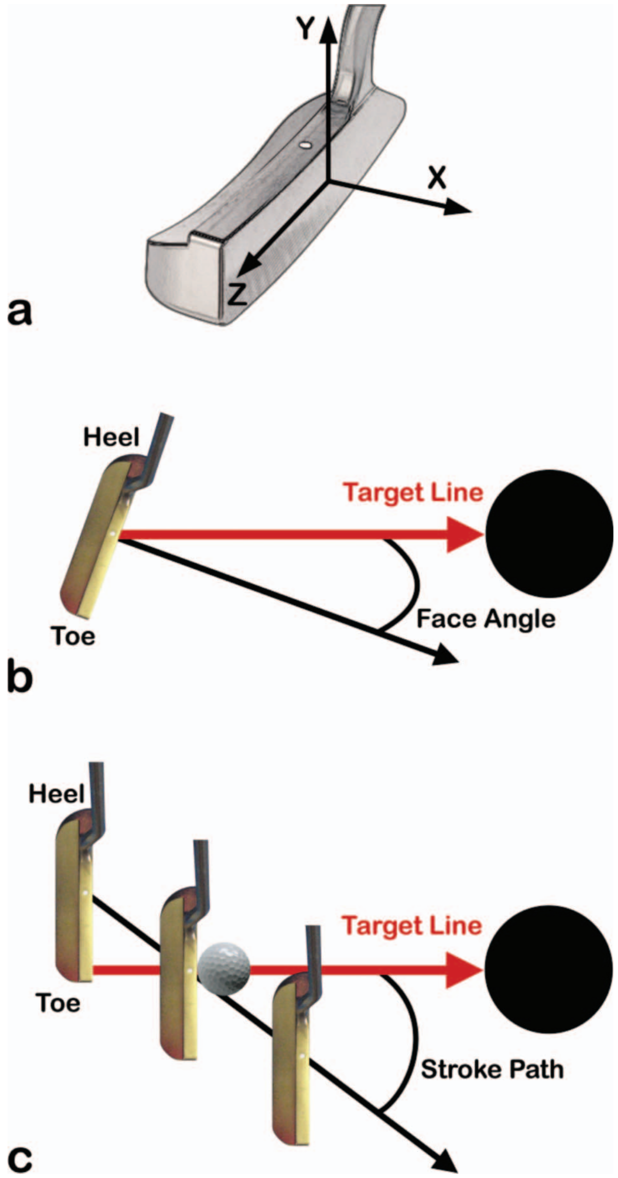

Figure 1. (a) Inertial frame of reference; (b) Face angle measurement convention; (c) Stroke path measurement convention.

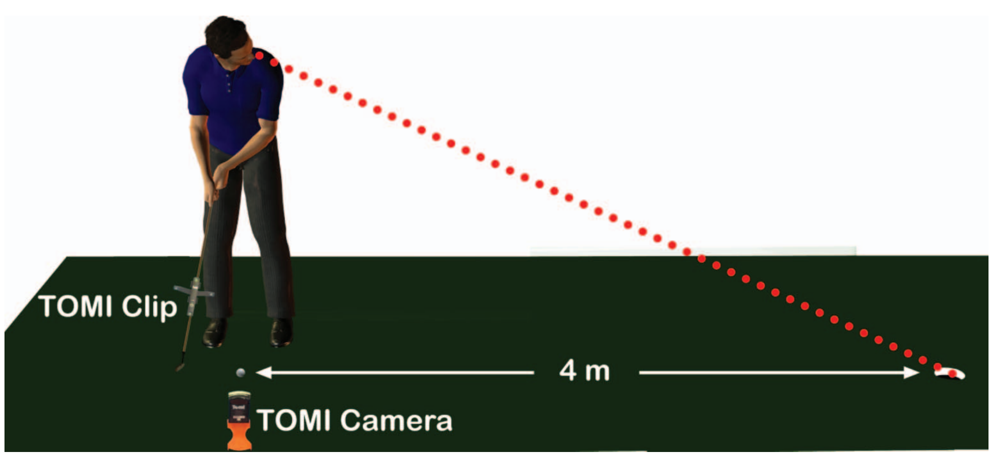

Figure 2. A 4 m putt, executed while visually focusing on the far target, is captured with the TOMI system.

success. There is an optimal speed associated with each putt (Pelz & Frank, 2000), as such, a putting robot was used to determine the optimal putter speed for holing putts from both the 1.22 m and 4 m distance (MacKenzie & Evans, 2010).

Practice

Participants were divided into two matched groups, based on their pretest putting performance, to control for the level of putting skill in each group. One group practised using the traditional visual technique of focusing on the ball throughout the entire stroke, while the second group practised while visually focusing on the hole. For the far target gaze technique, the participants were instructed to turn their head (body posture from the neck down was unchanged) until the hole was "clearly visible through both eyes" (Figure 2). A complete stroke was then executed with the gaze remaining focused on the hole. Participants attended five individual practice sessions spread out over a 4-week period. During each practice session participants hit 50 putts from a distance of 1.22 m and 50 putts from a distance of 4 m. These 100 putts were broken down into blocks of 25 putts and a 2-min break was taken between each block. The number of successful putts in the first and last practice session were recorded as an overall measure of putting performance. All practice sessions were supervised by a researcher to ensure that the correct technique was being used and that participants were motivated to perform optimally on each putt.

Statistical analysis

Putting success, as determined by the putting percentages in the first and last practice session, was entered into a $2 \times 2 \times 2$ (session $\times$ distance $\times$ group) analysis of variance (ANOVA) to detect any significant differences. The difference between the optimal putter speed and the actual was entered into a $2 \times 2 \times 2 \times 2$ (test $\times$ distance $\times$ group $\times$ gaze) ANOVA to detect any significant differences. Standard deviation in putter speed, for each set of five putts, was entered into a similar ANOVA. The standard deviation of face angle, stroke path, and impact spot, for each set of five putts, were entered as the dependent variables into a $2 \times 2 \times 2 \times 2$ (test $\times$ distance $\times$ group $\times$ gaze) multivariate analysis of variance (MANOVA). Prior to performing the statistical tests the data were checked for outliers as well as the assumptions of normality, homogeneity of variance-covariance matrices, linearity, and multicolinearity (Tabachnick & Fidell, 2001). None of the statistical assumptions were violated. The software package SPSS (Statistical Package for Social Sciences 15.0, SPSS Inc., Chicago, IL) was used for all statistical calculations.

Results

The main effect for session, which compared all putts between the first and last session regardless of group or putt length, indicated that following practice, there was a significant increase in the number of successful putts, $F(1,29) = 13.07$, $p = .001$ (Figure 3). To determine if significant improvements were made for both groups, two separate follow-up ANOVAs (session $\times$ distance) were performed for each group. Considering only the near group, there was a significant improvement in putting success from the first to last session, $F(1,15) = 5.94$, $P = 0.028$. From 1.22 m, the near group improved from an average of 79.9% in the first practice session to an average of 84.6% in the final session, while from 4 m, the near group improved from an average of 26.8% in the first practice session to an average of 32.3% in the final session (Figure 3). The far group also demonstrated a significant improvement in putting success from the first session to the final session, $F(1,14) = 7.07$ $P = 0.019$. From 1.22 m, the far group increased from 77.5% to 81.7%, while from 4 m, the far group increased from 24.5% to 32.8% (Figure 3). The main effect for distance indicated that significantly more putts were holed from 1.22 m than 4 m, $F(1,29) = 1676$, $P < 0.001$. To determine if significant improvements were made from both distances, two separate follow-up ANOVAs (session $\times$ group) were performed for each level of distance. The main effect for session from 1.22 m as well as the main effect for session from 4 m were both statistically significant; $F(1,29) = 5.17$, $P = 0.031$, and $F(1,29) = 11.02$, $P = 0.002$, respectively. No significant differ-

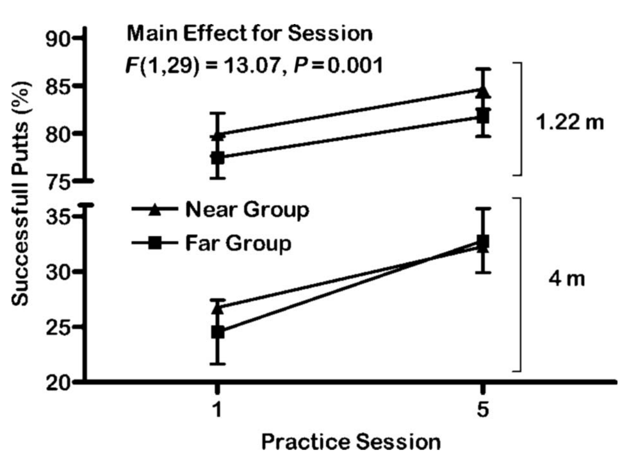

Figure 3. Percentage of putts successfully holed in the first and last practice sessions. The two putt lengths (1.22 m and 4 m) are plotted separately. Each group practised using only one of the two methods.

ences were found between the groups, or for any of the following interactions: session × group, session × distance, group × distance, or session × group × distance.

Regardless of test, distance, group, or gaze the actual putter speeds were found to be significantly lower than the predicted optimal speeds. Also, regardless of test, group, or gaze technique, participants putted significantly closer to the optimal speed from 4 m (-13.8 cm · s^{-1}) in comparison to the optimal speed from the 1.22 m distance (-18.3 cm · s^{-1}), $F(1,29) = 36.8$, $P < 0.001$. No other test results from this ANOVA were significant.

Those who practised focusing on the hole demonstrated significantly reduced putter speed variability, relative to the near group, following the five practice sessions, $F(1,29) = 6.36$, $P = .017$ (Figure 4). When just the far group was analysed, it was determined that there was a significant main effect for test, $F(1,14) = 9.06$, $P = 0.009$, but that the test by gaze interaction was not significant, $F(1,14) = 0.417$, $P = 0.529$. This implies that practising with the far gaze technique resulted in improvements in putter speed consistency while using both the far and near gaze techniques. Also, regardless of any other condition, there was significantly more variability in putter speed from 4 m (2.6 cm · s^{-1}) in comparison to the 1.22 m putt length (1.8 cm · s^{-1}), $F(1,29) = 39.5$, $P < 0.001$. No other test results from this ANOVA were significant.

Similar to the variability in putter speed, an analysis of the MANOVA results revealed that only distance (1.22 vs. 4 m) had a significant influence on the three dependent variables (face angle, stroke path, and impact spot), $F(3,27) = 9.78$, $P < 0.001$. A more specific analysis of each dependent variable, based on individual ANOVAs, revealed that both face angle variability and impact spot variability were significantly greater from 4 m (0.99°, 0.46 cm) relative to the 1.22 m putt length (0.75°, 0.36 cm), $F(1,29) = 20.6$, $P < 0.001$, $F(1,29) = 20.5$, $P < 0.001$. There was no significant difference in stroke path variability between distances, $F(1,29) = 0.5$, $P = 0.484$.

The following results, derived from follow-up ANOVAs on each dependent variable after the initial MANOVA, are the most relevant to the study. To simplify the presentation, the practice groups have been collapsed together. This is reasonable since the type of practice did not have any statistical or practical influence on these dependent variables. The two putt lengths have also been combined since distance did not have any significant interactions with the other independent variables. Considering impact spot variability, the main effect for gaze approached significance, $F(1,29) = 3.63$, $P = 0.067$, with the far gaze technique generating higher variability (0.43 cm) in comparison to the near gaze technique (0.38 cm) (Figure 5). However, from a practical perspective, this additional variability in impact spot (0.05 cm) would have a negligible increase on the likelihood of a missed putt (0.67%). This estimate was based on the following reasoning. Applying the findings from MacKenzie and Evans (2010) and Nilsson and Karlsen (2006), we can estimate that an off-centre contact of at least 11 mm is required to miss a 4 m putt. Assume that impact spot for a series of putts by one golfer follows a normal distribution with a mean of 0 and a standard deviation of 4.3 mm (Figure 5: Far Gaze). A mishit of 11 mm gives a z-score of 2.56 (11/4.3). Based on this z-score, the probability of this golfer being off-centre by 11 mm or more is 1.05%. If the impact spot variability improved from 4.3 to 3.8 mm (Figure 5), the likelihood of missing a 4 m putt would be reduced by 0.38%. Variability in face angle was approximately 0.1° higher with the far gaze technique, during both the pretest and posttest, but the main effect for gaze was not significant, $F(1,29) = 0.25$, $P = 0.622$ (Figure 6). Variability in

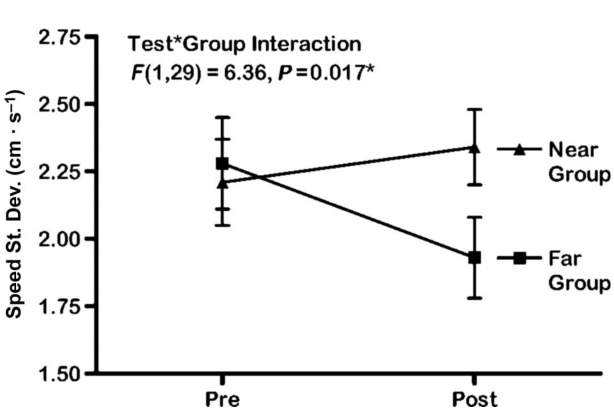

Figure 4. Putter speed variability as measured at impact. The two putts lengths and two gaze techniques are collapsed together.

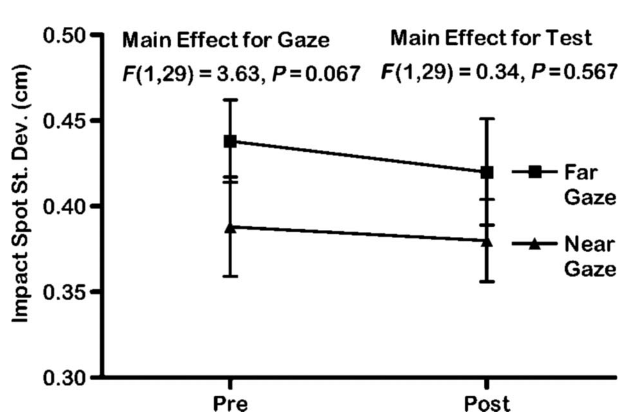

Figure 5. Variability in impact spot. The two putt lengths and two practice groups are collapsed together.

stroke path showed a slight increase in the posttest for the near gaze, and a slight decrease for the far gaze; however, the gaze by test interaction was not significant, $F(1,29) = 1.25$, $P = 0.273$ (Figure 7).

Discussion

The initial direction a golf ball will travel after contact with a putter is determined by impact spot, face angle, and stroke path (MacKenzie & Evans, 2010; Pelz & Frank, 2000). In this study, as suggested by the aforementioned variables, a golfer's ability to start the ball on the intended target line was not affected by visually focusing on the hole, instead of the ball, throughout the stroke. The differences in the variability in impact spot, face angle, and stroke path, between the two visual conditions, were neither statistically significant, nor practically meaningful (Figure 5, Figure 6, and Figure 7). Given that the initial direction of a putt is a major determinant of success, these results on the quality of impact are supported by the findings of Aksamit and Husak (1983), Bowen (1968), Cockerill (1979), and Gott and McGown (1988), which all showed no significant differences in putting success when golfers visually focused on the hole instead of the ball. It is worth noting that, for the far gaze technique, there were improvements in all variables representing the quality of impact, on the posttest, in comparison to the pretest. With the exception of stroke path, the same was true for the near gaze technique. The summation of these small improvements was the probable determinant of the statistically significant improvement in putting success following practice (Figure 3). The percentage of putts sunk in the present study was similar to that of other putting studies from similar distances (Gott & McGown, 1988). Given the relatively low requirements of the musculoskeletal system (e.g., range of motion, activation level, and coordination) to execute the putting stroke, it seems reasonable that accurate contact can be made without focusing on the ball. Further, golfers are permitted the time to reproduce the same physical position of their body, relative to the ball and target line, on every putt, regardless of putt length, slope, or break. The simplicity of the movement, and ample preparation time, may explain why the type of practice did not appreciably affect the quality of impact variables. Perhaps the 10 warm-up putts, during each testing session, were sufficient for the participants to become relatively proficient at accurately contacting the ball while focusing on the hole. However, since all of the putts in this study were executed on a flat surface, it is possible that the sloped surface of a real green might have a moderator affect on the relationship between the location of visual focus and the quality of impact.

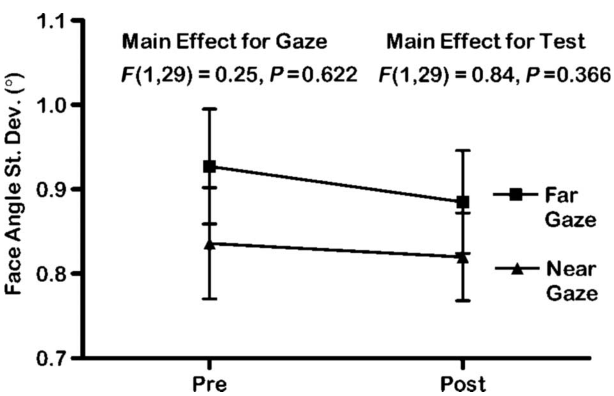

Figure 6. Variability in face angle as measured at impact. The two putt lengths and two practice groups are collapsed together.

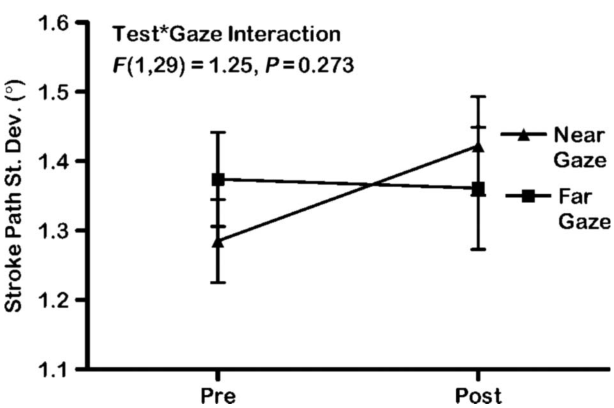

Figure 7. Variability in stroke path as measured at impact. The two putt lengths and two practice groups are collapsed together.

Contacting the ball with the appropriate putter speed is at least as important as starting the ball on the correct line. The golfers who focused on the hole throughout the practice sessions demonstrated a significant reduction in putter speed variability, from pretest to posttest, relative to the golfers who focused on the ball during practice (Figure 4). This could be related to the idea that, while focusing on the hole, the participants were not forced to retain an image of where the hole was located in memory (Vickers, 1992). Laabs (1973) found that memory of distance meaningfully decayed in a few seconds, as would be the case when the near target golfers focused on the ball, instead of the hole, immediately before initiating the putting stroke. This is supported by Vickers (1992), who found that distance errors accounted for 60.5% of all misses. Vickers hypothesised that a contributor to problems in gauging distance may be that golfers take too long between setting-up the distance cue and actually delivering the putt; therefore, increasing the probability that it is forgotten. This would not be an issue during far target-oriented putting. Golf professionals are also of the belief that assessing distance to the hole is more difficult than judging the line (Nicklaus & Bowden, 1998). Similarly, Pelz and Frank (2000) suggested that imparting the ball with the correct speed is four times more important than the correct line. In testing that provided amateurs with perfect aim direction, on a 12-foot (3.7 m) putt with a 4-inch (10.2 cm) break, they determined that 80% of the missed putts were due to improper speed. It should be noted that Pelz and Frank used breaking putts, which are more sensitive to speed variations, while Vickers employed straight putts; this probably accounts for the differing percentages. Compared to the putting surface used in this study, an actual green typically would require more information to be analysed. Consider an uphill (or downhill) putt. In judging the correct amount of speed to impart to the ball, the golfer must retain both the distance to the hole, and the amount of slope, in memory when using the near gaze method. As such, it is hypothesised that, on real greens, a far target gaze approach may surpass the traditional method for average golfers, such as those tested in this study. For professional golfers, who have honed their ability to retain the distance cue in memory, focusing on the far target may provide no benefit.

Visually focusing on the far target during the stroke may result in a golfer directing their focus of attention on the effect of their movements (external focus), such as concentrating on rolling the ball into the hole. In contrast to an external focus, a golfer may concentrate on the pendular movement of their hands (internal focus) during the stroke. The majority of research suggests that maintaining an external focus of attention results in improved success across a variety of skills including golf (Perkins-Ceccato, Passmore, & Lee, 2003; Poolton, Maxwell, Masters, & Raab, 2006; Wulf, Lauterbach, & Toole, 1999; Wulf, McConnel, Gärtner, & Schwarz, 2002; Wulf & Prinz, 2001; Wulf, Tollner, & Shea, 2007). It has also been shown that increasing the distance of the external focus enhances success (McNevin, Shea, & Wulf, 2003). Considering the putting stroke, this line of reasoning suggests that focusing on the movement of the club is better than focusing on the movement of hands, but that concentrating on rolling the ball into the hole may be best. Although visual focus is separate from attentional focus (McNevin et al., 2003), it seems reasonable to assume that visually focusing on the far target would promote an external focus of attention during the stroke.

On average, golfers under all conditions generated significantly less putter speed than was determined to be optimal. This was probably a result of the participants not realising how fast an optimal putt should be travelling when it reaches the hole. For example, when questioned following the completion of the study, the majority of participants thought that a putt that had just enough speed to reach the hole was optimal. For the synthetic green used in this study, it was determined that the optimal speed would roll the ball approximately 45 cm past the hole. As the participants were not given feedback on the optimal speed, an improvement in this variable on the posttest was not expected. Amateur golfers, such as the participants in this study, tend to underestimate the speed with which to strike the ball (Pelz & Frank, 2000). This underestimation may have been enhanced in the present study due to the relatively fast speed of the synthetic surface (Stimp = 11.5); however, faster surfaces (Stimp = 13) have recently been used for conducting putting research with less skilled golfers (Lee, Ishikura, Kegel, Gonzalez, & Passmore, 2008).

In this study, all putts were executed on a nominally flat surface, which meant that the target line always bisected the hole; therefore, the far target was always the hole. The authors suggest that if the far target-oriented method is used on breaking putts, then a spot along the intended target line, not the hole, should be visually focused on throughout the stroke. This visual aiming strategy is employed in the sport of curling. In delivering the curling stone, curlers will turn the stone during the release resulting in the stone following a curved path along the ice. Before producing such a curved path, curlers will aim towards, and visually focus on, a spot at the far end of the ice that is collinear with the intended initial velocity of the stone after release. They do not visually focus on the location where they intend the stone to eventually come to rest.

There is another potential benefit of focusing on the far target, which was not specifically investigated in the present study. A common technique flaw, in traditional putting, reported by both golfers and instructors, is "looking up" during the stroke. Presumably, this motion is initiated because the golfer is anxious to determine the fate of the putt. In fact, Harmon (2007) believes that looking up too soon is a major cause of missed putts and suggests focusing on the spot where the ball was located until hearing the ball drop in the hole. While employing a far target gaze technique, the motivation to change the head position should be removed since the ball will eventually come into the golfer's view, which would already be focused near the hole on most putts.

Conclusions

Visually focusing on the hole, instead of the ball, throughout the duration of the putting stroke did not meaningfully (nor statistically) affect the quality of the impact between the putter face and ball.

Quality of impact was assessed by measuring the variability in face angle, stroke path, and impact spot at the precise moment the putter head contacted the ball. Completing five sessions, in which putting while visually focusing on the hole was practised, resulted in a statistically significant reduction in putter speed variability, at impact, in comparison to practising while visually focusing on the ball.

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