THE EFFECTS OF VISUAL PERSPECTIVE, BALL POSITION AND DISTANCE ON THE ACCURACY OF A PUTTED BALL IN GOLF

by

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Running head: VISUAL PERSPECTIVE

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Abstract

The influence on putting accuracy due to the position of the eyes relative to the ball, the position of the ball relative to the stance and the distance of the putt was determined. Putts were performed by thirty-two beginning golfers on a level indoor putting surface from distances of 6 and 15 feet. Dependent measures included putts made (hit data) and putts not made (miss data which was measured in the X [long,short] and Y [left,right] directions). Results indicated that overall, the forward ball position was most accurate, possibly due to its stabilizing effect on the stance. On shorter putts, it is recommended that the eyes be positioned over the ball. A reasonable view of the target is achieved from this position and, in combination with the forward ball position, yielded accurate results. On longer putts the eyes should be positioned along the ball-target line since the view of the target appears to provide an important advantage in terms of putting accuracy. There appears to be an as yet undetermined optimal range for accuracy for the eyes along the ball-target line position. Results of this study may be applicable only to putts performed on a level surface.

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The Origins and History of Golf

The game of golf is one of the oldest of today's popular sports. "But its exact beginnings are lost in antiquity. Some historians trace golf back to the stone age ..." (Scharrf, 1973, p.1) whereas others believe the game had its beginnings with the ancient Romans. The Romans played a game called "pagnacia" in which a bent stick, a ball stuffed with feathers and the open countryside were used. Roman occupation of Europe in first century B.C. resulted in Romans occupying some parts of England and Scotland, where they remained for almost 5 centuries. "It is therefore assumed by most historians that their game of pagnacia, with its feather ball, was the forerunner not only of golf, but of kindred games played in Holland, Belgium, France and England" (p.1).

While Rome may take credit for the origins of the game, Scotland is credited with devising the game of golf as we now know it. Indeed, the Scots enjoyed the game so much that in 1457 the Scottish parliament of King James II declared golf illegal because the King was fearful that skill at golf would replace skill with the bow and arrow. This was thought to have dangerous

consequences for the defense of Scotland (Scharrf, 1973). With the introduction of gunpowder at the end of the 15th century, the ban on the game was lifted.

In 1744, the Honourable Company of Edinburgh Golfers was established which was the first known organized golf club (Scharrf, 1973). Ten years later the St. Andrew's Society of Golfers was born, and is now known as the Royal and Ancient Golf Club at St. Andrews. St. Andrews is still known for its rich golfing heritage. Formal rules for golf were introduced in the late 1700's and the game expanded to England, the United States and Canada in the 1800's. "The oldest continuous club in North America is the Royal Montreal Golf Club, organized in 1873" (Scharrf, 1973, p.8).

Golf continued to grow in the twentieth century, a growth which included play at both the amateur and professional levels. The advent of television helped popularize the professional tour and gave amateurs heroes they could emulate. The golfing industry has become big business worldwide. This includes large volume sales of golf equipment and clothing as well as

the large money purses played for by today's professionals in tour events (Scharrf, 1973).

The spiralling growth in the game's popularity is apparent when viewed from a global perspective. Golf is growing in popularity in North America as well as in Europe and Australia (Stirk, 1987). In the spirit of "glasnost" the Soviet Union has developed its first golf course and driving range. In Japan, the lack of horizontal space combined with the high population density and the game's popularity creates a situation where golf courses are scarce and the Japanese often have to travel to other countries to play the game (Stirk, 1987). As golf's popularity as a participant sport increases worldwide, the need for proper instruction for those new to the game is amplified.

The Importance of Putting

Golf is a target sport. "The object of golf is to play a round, usually 18 holes, in as few strokes as possible" (Nance & Davis, 1985, p.1). The "putting cup" or "hole" represents the final target to be hit by the golfer on each of the eighteen holes. This is normally accomplished by "stroking" or "putting" a golf ball with a club called a "putter" into the 4 1/4"

putting cup or hole. The more proficient the player, the fewer strokes it takes to putt the ball into the cup. As well, a low score for a round of golf is deemed more successful than a higher score. Golf scores are measured against "par". "Par golf is a standard of scoring excellence based on the length of the hole and allowing two putts on the putting green" (Nance & Davis, 1966, p.1). Putts account for 67% of the strokes allowed for a par three hole, 50% for a par four hole and 40% for a par five hole. Thus, on an average course with a par rating of 72 for 18 holes, 36 strokes allowed to par are designated for the skill of putting.

Mahoney (1982) feels that putting plays an important role in producing good golf scores. Professionals too realize the importance of putting. "One of the most commonly held axioms in golf is `You drive for show and putt for dough'" (Gott & McGown, 1988, p. 139). Nance and Davis (1985) go so far as to say that you must be a good putter in order to score well. Dante (1978) quotes an old Scottish proverb when he states, "A mon who can putt is a match for any mon" (p.90).

One of the fundamental reasons that most golfers score poorly is due to poor putting. Not only can good putting help to lower a player's score by taking strokes directly off the score card, but it can help to improve the rest of an individual's game as well. Player (1967) notes that there is a psychological advantage that can take place when a putt is sunk. He feels that the player's confidence is boosted and this results in increased confidence in other facets of the game including the tee-shot directly following the putt made. Conversely, Player feels that poor putting "...builds fear and frustration" (p.98).

Despite the emphasis professionals and instructors place on the importance of putting, "the average golfer takes approximately 38 to 42 putts per round" (Scharrf, 1973, p. 280). This, in part, accounts for the fact that less than 1% of golfers in the United States regularly shoot par or better (Keogh & Smith, 1985).

Variables Affecting the Level of Difficulty in Putting

Teaching professionals and instructors often contradict one another regarding both teaching of putting and the styles used for putting. This makes it more difficult for the beginner to become consistent

and develop a "repeating" stroke. Repeatability has been cited as a secret to winning golf (Nicklaus, 1983). "It may be that different styles produce the same overall accuracy, but if one style produces less variability, especially if the variability is close to the hole, it would be preferred because a greater percentage of second putts could be accomplished" (Gott & McGown, 1988, p. 139).

In addition to the lack of standardization in golf instruction, there is a lack of standardization regarding the equipment that golfers use. Golfers can choose from a wide variety of styles when choosing a putter. As well, the golf balls used in the game are not all identical (which differs from other sports such as baseball, football, soccer etc.). Balls can be one piece (solid core) or two piece (wound core enclosed in a tough outer cover). Differing "dimple" patterns give the ball its aerodynamic effects as well as a certain degree of "feel". These patterns vary from one ball to the next.

Golf courses have "greens" for putting on and there are no two that are exactly alike. Some are relatively flat wheras others are sloped to varying

degrees. In addition to slope, imperfections in the putting surface can increase the level of difficulty in putting. Consider that "even a perfect putting machine was able to hole only 50 percent of its putts from a 20' distance due to irregularities even on a good putting surface" (Wiren, 1971, p.103).

Direction and the affect that slope have upon a putt have been established. Distance is another variable that the golfer must negotiate in order to be successful in holing out a putt. The correct distance is accomplished by estimating the appropriate club head speed. Jones in All About Putting (1973), notes that "... for a ball going fast the hole is really only an inch wide ..."(p.24) however "... if the speed is right, the ball may go in the front, back or sides" (p.24).

The fact that golfers spend much less time practicing putting relative to the amount of time spent practicing other shots results in shortcomings in putting proficiency for the average golfer. Indeed, people don't practice their putting enough. Hammond (1975) noted that sports participants in several events do not practice enough to keep improving. For the

majority of golfers, the same can be said about practice of their putting skills. Development of sound mechanics and putting fundamentals is important if the golfer is to overcome the many variables associated with putting.

The Role of Vision in Putting

An increase in research regarding the role of vision in putting is warranted if we are to understand it's influence on putting accuracy. Bowen (1957) examined the role of visual orientation in the putting stroke. Two groups of male golfers were instructed in two methods of putting. The experimental group was permitted to look at either the cup or the line that the putt would travel but not at the ball. The control group could only look at the ball. Loften (1957) in reviewing Bowen's conclusions noted that:

(1) beginning golfers tend to over-putt short putts;

(2) with longer sloping putts beginners tend to underestimate the effect of the slope, "however as the length of the putt increases there is less underestimating the effect of the hill" (p.34-35).

(3) "that the probable factor in controlling the errors in length of putt on the undulating surface was the final downhill roll toward the cup" (p.34-35).

According to Cowles' (1974) interpretation of the Bowen study, neither method of visual orientation was significantly different from the other.

Some professionals feel that ball positions should be determined by the golfer's dominant eye. Spork (1972) has asserted that golfers with a dominant left eye should putt from the centre of the stance and those with a dominant right eye should putt off the left foot.

There is considerable support for the <u>eyes over the ball</u> theory of putting. According to Nance and Davis (1985), "the eyes are directly above and looking straight down on the ball ... the ball is played from a point opposite the inside of the left heel to a point opposite the center of the stance. If the ball is played toward the left side, more weight may be carried on the left foot" (p.58). Cheatum (1975) feels that the ball should be positioned in line with the large toe of the left foot. He also advocates standing with

the eyes over the ball. Keogh and Smith (1985) initially advised golfers to keep their eyes over the ball but later said the eyes should be situated directly over the clubhead.

Similarly, there is support for the eyes along the ball-target line theory. Cowles (1974) supports positioning the eyes over the ball-target line and "... slightly behind the ball" (p.67). Crampton in All About Putting (1973) notes that Jack Nicklaus has felt best when setting up with his eyes behind the ball. From this setup position Nicklaus feels he is able to look through the ball to the target which may enhance his ability to stroke the putt in the intended direction.

Nicklaus (1974) does

> ... not believe that it is optically possible for the normally sighted person to attain a correct visual impression of the line of a putt at address unless his eyes are positioned directly above the ball-target line. If the eyes are positioned inside this line, the putting line `seen' will actually go to the right of the hole. If the eyes are outside the ball-target line, the seemingly

correct putting line will actually go left of the hole. (p.249)

Pelz (1990) believes that good putting depends on proper aim (which includes proper body and putter alignment with the target). He notes that the eyes play a pivotal role in the golfer's ability to aim properly and that "... few golfers, including Tour pros, putt with their eyes in the position that will do the most good: directly over the target line ... if you dropped a plumb line from the bridge of your nose, it should touch a spot on the target line" (p.77). Stephenson (1986) agrees that the eyes should be on the same line as the ball.

Crenshaw (1986), considered by many to be the number one putter on the P.G.A. tour, says that he doesn't conform to either the eyes over the ball theory or the eyes along the ball-target line theory. Instead, he concentrates on putting his hands on the ball-target line. He does stress that the putter must be square to the intended target at impact.

Cowles (1974) in a study of golfers with a handicap of 7 or lower attempted to analyze factors common to the most successful putting styles in golf.

He concluded that the position of the eyes should be along the ball-target line and slightly behind the ball. He recommended that "a study be conducted to compare the effectiveness of putting while watching the ball and putting while watching the hole, using golfers of all skill levels" (p.68).

Cockerill (1980) complied with Cowles' recommendation and conducted a study in which two groups of right handed males (one group of golfers and one group of non-golfers) putted under two conditions (eyes watching the ball and eyes watching the hole). Putting distances were set at 100 and 200 centimeters. It was discovered that as distance from the hole increased, distance error increased among all subjects. While non-golfers scored better when watching the ball, golfers showed little difference in performance for the two conditions. Cockerill (1980) concluded that neither strategy proved to be better for putting accuracy. A secondary finding of the study was that more putts rolled to the right of the hole when subjects watched the ball as compared to watching the hole. Cockerill feels that when a person focuses their

eyes on the hole, directional accuracy improves, however he stressed that more research was necessary to substantiate the reliability of the result. "Watching the target ... may prove the better overall strategy, not only for effort control, but also for directional accuracy" (p.383). He concluded that golfers should attempt to stroke approach putts to within 2 metres of the hole. Within this range distance effort control has been demonstrated to be more accurate. Cowles (1974) observed that research on putting methods was scarce and Hay (1978) stressed that there is a lack of knowledge about the most appropriate putting techniques.

Cochran and Stobbs (1968) performed a cinematographical analysis of the putting stroke of 16 "first class" professional golfers. Golfers were consistent only in their ball position and head position. The majority positioned the ball opposite the left foot and the eyes directly over the ball.

Whiting and Cockerill (1972) divided males into four age groups (5-6 yrs., 10-11 yrs., 15-16 yrs., and 18 + yrs.) which did not correspond to years of golf experience. The study involved "aligning a Fletcher's

trolley with a pointer placed at varying distances adjacent to an inclined wooden track" (p.155). Half the subjects were allowed to view both their hands and the target (pointer). The other half of the subjects were permitted to see neither. Accuracy was improved when individuals could see the target during task performance. Differences were significant for all but the oldest group. The youngest group exhibited the greatest difference in performance. Whiting and Cockerill explained that their highly inaccurate non-vision performance "... may be partly explained by their inability to maintain a mental image of the distance to the target after it was screened off. Practical implications for research in this area within a sports context appear to relate to such aiming tasks as putting in golf ..." (p.161).

Whiting and Cockerill (1974) conducted a similar study with males of three age groups (6-7 yrs., 10-11 yrs., and 19 + yrs.) in which subjects were asked to "propel a trolley ballistically up an inclined plane to match a predetermined stopping point" (p.27). They concluded from the study that viewing the target

results in greater accuracy than watching the hand. There are however, several ballistic actions in sport where performers do not look at the target as the object is being propelled.

> Probably the most obvious is putting in golf. Here a player is required to make contact with a ball, and, using `just enough' effort, engage a distant target. It is proposed that, when putting, the golfer prefers to look at the ball, rather than the hole, in order to maintain the putter blade in correct alignment with the hole. (p.32)

It is Cockerill's opinion that "when individuals are able to hold an object to be projected at a target they invariably attend to the target when taking aim, thereby affording themselves continuous monitoring of perceived distance between the projectile and the target. However, when putting a golf ball, perhaps in order to ensure that the club head makes good contact, vision is focused upon the ball with the associated need to remember the precise distance from ball to hole. Since concentrating upon making a sound stroke is likely to be greater than upon retaining an image of

target distance, it is likely that there will be rapid decay in maintaining the latter" (1980, p.378-379).

In 1983, Aksamit & Husak had right handed female volunteers putt under 3 different conditions (eyes on the ball, eyes on the target and no vision). As distance was decreased, putting accuracy increased. There were no marked differences between the 3 conditions. The authors argued that the "elimination of vision may enhance learning in the early stages of putting skill acquisition" (p.19). Additionally, "if neither looking at the target nor the object is a better strategy for decreasing putting errors, then kinesthesis must be of equal or greater importance for putting than vision" (p.21).

Wannebo and Reeve (1984) conducted a study in which subjects who were classified as either high or low skill putted from two distances (5 feet and 15 feet) under three different conditions (visual cues - look at ball; no visual cues - blindfolded; and irrelevant visual cues - looking at an offset marker). Subjects were more accurate from the 5 foot distance than the 15 foot distance. Radial error measures indicated that the greatest accuracy was achieved when

subjects received relevant visual cues (M=11.8 in.). No differences were found for subjects putting in either the visual cue (M=18.5 in.) or the irrelevant visual cue (M=19.5 in.) conditions.

These findings differed from those of Aksamit and Husak (1983) who found no differences between subjects putting with visual cues or putting blindfolded. It was explained that this may be due to the subjects themselves. Aksamit and Husak tested non-golfers whereas Wannebo and Reeve's subjects were students enrolled in a golfing class. It was concluded that golfers learn to rely on relevant visual cues quite early in the skill acquisition process (Wannebo and Reeve,1984).

Gott and McGown (1988) used 4 different putting teaching methods (conventional stance, eyes on the ball; conventional stance, eyes on the hole; side saddle stance, eyes on the ball; side saddle stance, eyes on the hole). In the conventional stance, the body and feet are lined up at right angles to the target or hole wheras in the side saddle putting method, the body and feet are facing the target or hole.

For each of the two distances utilized (5 and 15 feet), no significant differences were found for any combination of stance and point of aim. This contradicts the popular opinion that the conventional method is the most effective. Gott and McGown (1988) concluded that "... other methods are equally as good and could be used if individually desired" (p.139).

A grid system for measuring the accuracy of a putted ball was used in the Gott and McGown (1988) study. While increasing the experimenter's ability to accurately assess putting ability, the grid system also enables the experimenter to estimate variability around the target. A situation may arise whereby there are no differences in overall accuracy between two styles of putting, however one style produces less variability (that variability occurring closer to the hole). A style with the variability close to the hole is preferred "... because a greater percentage of second putts could be accomplished" (Gott and McGown, 1988, p.141).

Although putting is a target skill, it is different visually from other target skills such as riflery or archery. "In those sports, one eye always

looks down the target line - down a gun barrel or along an arrow when drawing a bead on the target" (Pelz, 1990, p.77). Thus, sighting the target from directly behind the object to be propelled or the weapon to be used enhances the ability to "line up" or effectively "aim" so as to accurately hit the target.

Sam Snead was one of the most prolific golfers of the 1940's and 1950's. Late in his golfing career he attempted to create the same visual effect by utilizing the "croquet style" of putting in which the body and feet face the target with the ball centered between the feet and the line of vision directly behind the ball in line with the target. The idea that this different line of vision could influence putting was demonstrated by Kelliher (1963) in a comparison of the croquet style and the conventional method of putting. The croquet style demonstrated superior accuracy compared to the conventional method for longer putts. On shorter putts, there was little difference in accuracy between the two methods. The eyes along the ball-target line position partially simulates the visual perspective created by the croquet style (which is now banned by the United States Golf Association) by allowing the

eyes to look down a straight line from behind the ball and through to the intended target.

With the ban of the croquet style, the golfer must now stand to the side of the target line to putt the ball. This being the case, Pelz (1990) notes that the putterface will point to the target along one line while the golfer's eyes follow another line to the target (this is true where the eyes are not intentionally positioned down the ball-target line). As a consequence, the differences in orientation between the two lines would vary with the length of the putt. He believes this difference in orientation between the two lines could be a cause of many putts missed to the left or right of the hole.

The conventional style of putting features differing visual perspectives as the length of the putt changes. This fact may account for the findings of Kelliher's (1963) study. Indeed, lack of constancy in the visual perspective when lining up a putt may affect one's ability to properly line up the putterface with the intended target. According to Hay (1978), "the

direction in which the ball sets off is governed more by where the face of the putter is pointing than by the direction in which the head of the putter is moving. Having the blade `square' at impact is therefore the most important single point to concentrate on in holing out" (p.278). Utilizing a constant visual perspective in which the position of the eyes are always situated in line with the ball and the target may enhance proper alignment of the putterface, thus increasing the chances of holing out.

Rationale

There is a great amount of conflicting information and instruction available from both the golf putting literature and golf professionals. This makes the task of learning the game very difficult for beginners. According to Keogh and Smith (1985), "there is more controversy about the putting stroke than any other phase of golf. You will see more different techniques on a putting green than colours on a kaleidoscope" (p.285). Further, Hay (1978) states that "the present knowledge of putting techniques sheds very little light on what methods are most suitable" (p.276).

As reviewed in the previous section, a number of studies have focused on various aspects of the role of visual perspective and its importance with regard to putting accuracy in the game of golf (Aksamit & Husak, 1983; Bowen, 1957; Bowen, 1968; Cockerill, 1980; Cowles, 1974; Gott & McGown, 1988; Wannebo & Reeve, 1984). According to Wannebo and Reeve (1984), "Visual and kinesthetic feedback are important sources of sensory information in the learning and performance of motor skills" (p.611). Visual perception of an object varies with the line of sight in which it is viewed. In general, two popular schools of thought concerning the position of the line of vision for proper positioning of the putter prior to the putting stroke have emerged. The "eyes over the ball theory" (Cheatum, 1975; Keogh & Smith, 1985; Nance & Davis, 1985) and the "eyes along the ball-target line theory" (All About Putting, 1973; Cowles, 1974; Crampton, 1973; Nicklaus, 1974; Pelz, 1990; Stephenson, 1986) both receive considerable support from golf professionals and instructors. However, the paucity of scientific research regarding these two theories creates a need

for further investigation into their respective effectiveness.

In addition to conflicting opinions regarding the role of visual perspective in the putting stroke, there are also conflicting opinions regarding the proper position of the ball relative to the stance in golf putting. Some professionals indicate that the ball should be played opposite the instep of the forward foot in the stance. The reasoning is that, with the ball played forward in the stance, the putterhead will strike the ball with an ascending blow thereby creating more topspin on the ball as opposed to other ball positions in the stance. This should improve the chance of a putt toppling into the hole. Several professionals have played the ball in the centre of the feet or near the rear foot with equal success. Again, as with the position of the eyes relative to the ball, the lack of research regarding ball position in relation to the stance in golf putting creates a need for further investigation in this area. Standardized guidelines regarding these two putting parameters may be beneficial to newcomers to the game by allowing them to aim the putterhead properly. "So long as your aim

is poor, your putting stroke can't improve because you'll never know what's at fault - mechanics or alignment. Once your aim is true, you can work on honing your stroke ..." (Pelz, 1990, p.77).

In summary, conflicting information regarding the position of the ball in the stance and the line of vision used in lining up a putt create a need to determine the most effective positions for each.

Purpose

The purpose of this study was to:

1) Determine the influence on putting accuracy due to:
    a) the position of the eyes relative to the ball, and
    b) the position of the ball relative to the stance, and
2) Determine the influence of distance in determining the most effective putting style.

Method

Design and Statistical Analysis

The study utilized a 3 (ball position) X 2 (points of aim) X 2 (distance of putt) within subjects design.

The dependent measures included:

1) Putts Made; and

2) Putts Not Made.

For putts not made, the constant error was recorded in both the X and Y directions. Dependent measures were analyzed in 3 X 2 X 2 repeated measures analyses of variance. The level of statistical significance was set at P. < .05. Where appropriate, follow-up analyses were conducted using the Newman-Keuls procedure.

Subjects

Subjects were 32 volunteers, (21 males and 11 females ranging in age from 19 to 54 years) chosen randomly, from Canadian Forces Base Borden. Subjects consisted of beginning golfers with no prior formal golf experience so that previous putting experience or preferences would not bias the results. All subjects were right handed putters.

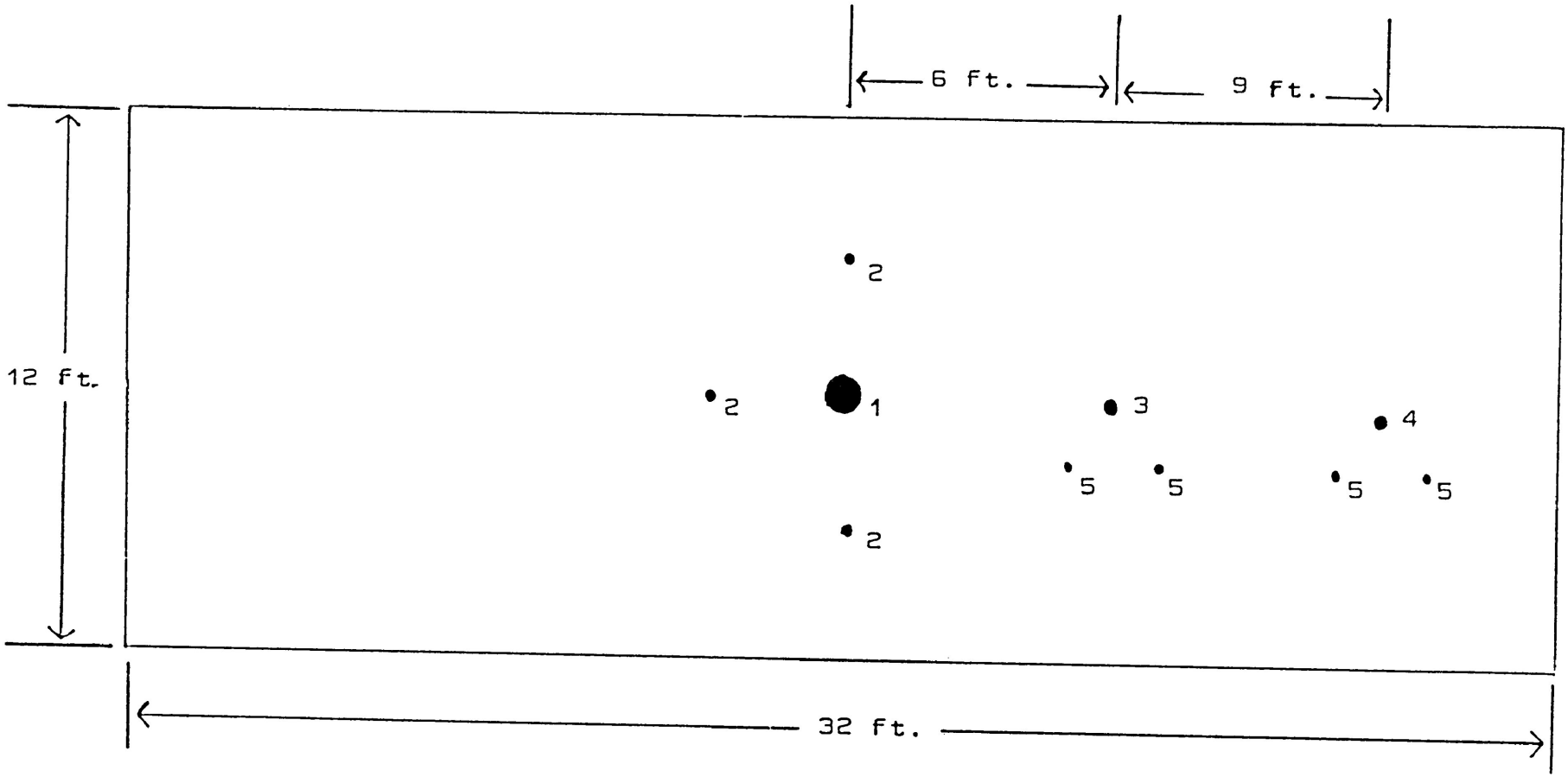
Apparatus

Putting trials were performed on a flat green carpeted surface measuring 12 ft X 32 ft (see Figure 1). The surface was similar to that used in many "mini-golf" setups. A simulated putting cup measuring

4 1/4" in diameter and cut from orange bristol board (to contrast with the green putting surface) represented the target. Two small dots drawn on the carpet at distances of 6 ft and 15 ft from the hole provided a constant location for ball placement for putts of corresponding distances. Adjacent to these ball placement marks were two more marks at each distance (these were mat placement marks - subjects could not see these during their attempts).

A straight line was measured (with a tape measure) extending from the hole through the two ball placement marks. A ruler was then placed perpendicular to this line to measure exactly 6" from the line for the two mat placement marks at each distance of putt. These marks were a distance of one foot apart, one mark for each distance being 6" closer to the hole and the other being 6" further from the hole.

The front edge of a foot placement mat (see Figure 2 and Figure 3) covered these marks during trials so that subjects had no swing reference guide. The foot placement mat was constructed out of orange bristol board and two feet were traced onto the mat with the feet facing straight ahead and with a distance of 12"



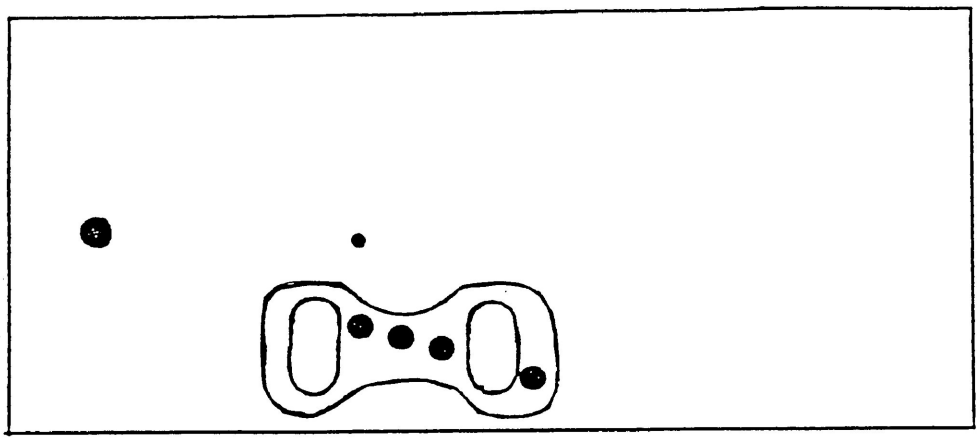
1 = Simulated Putting Cup
2 = Measuring Marks (not visible to subjects)(Distance = 3 ft. from hole)
3 = Ball Placement Position at 6 Ft. Distance
4 = Ball Placement Position at 15 Ft. Distance
5 = Marks for Lining Up Foot Mat (not visible to subjects)
(Distance = 6" From line from hole to ball positions)

Figure 1. Putting Apparatus

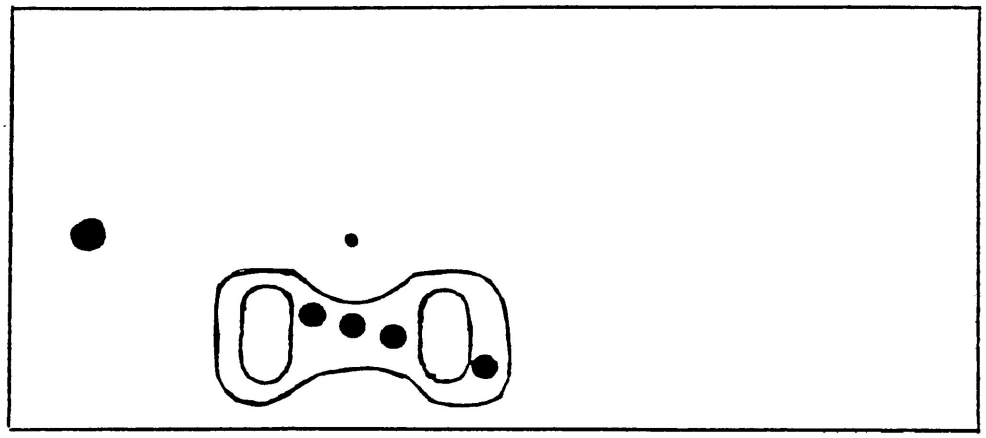
separating their insteps. This distance and foot position provided for a "shoulder width" square stance for each putt (stance is perpendicular to a straight line from the hole to the ball placement position).

Four dots were drawn on the foot placement mat, three between the two feet and one just outside of the right foot (see Figure 2 and Figure 3). For the dots between the two foot positions, one was just inside the left instep (for the forward ball position), one was located mid-stance for the mid-stance ball position (6" closer to the right foot) and the third was another 6" back to be located just inside the right instep (for the rear-stance ball position). The three dots to the right also doubled for plumb line placement (see Procedure). These dots were arranged on an angle so that subjects could not line up their putts by swinging parallel to the dots. Additionally, the shape of the foot placement mat was cut in a circular pattern so as to prevent a putting reference for subjects.

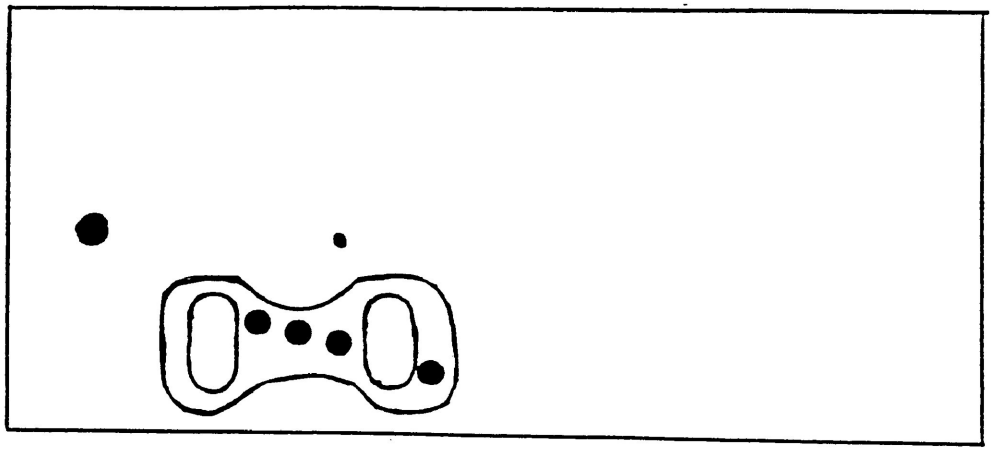
A 16 foot measuring tape and a yardstick were used to measure the exact resting place of putts that missed the target. A plumb line with 6 feet of string was used to attain exact head and eye position prior to



Ball Position = Forward in Stance

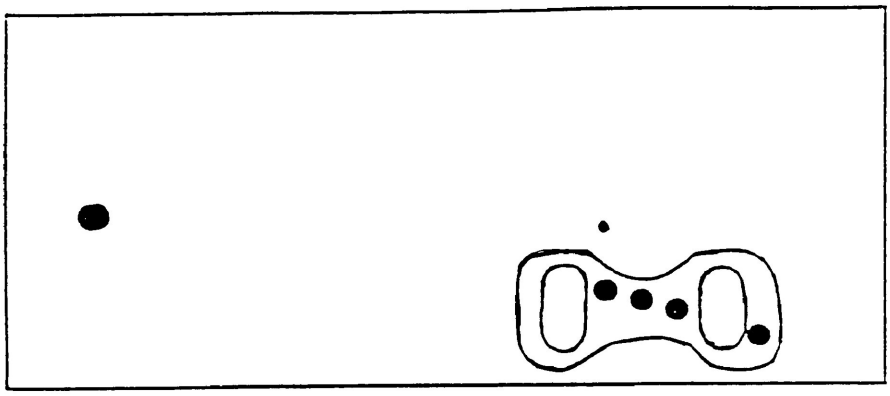


Ball Position = Mid-Stance

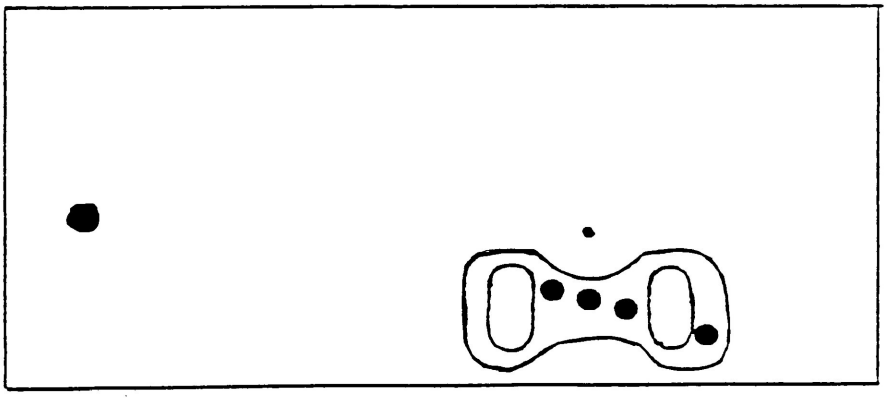


Ball Position = Rear-Stance

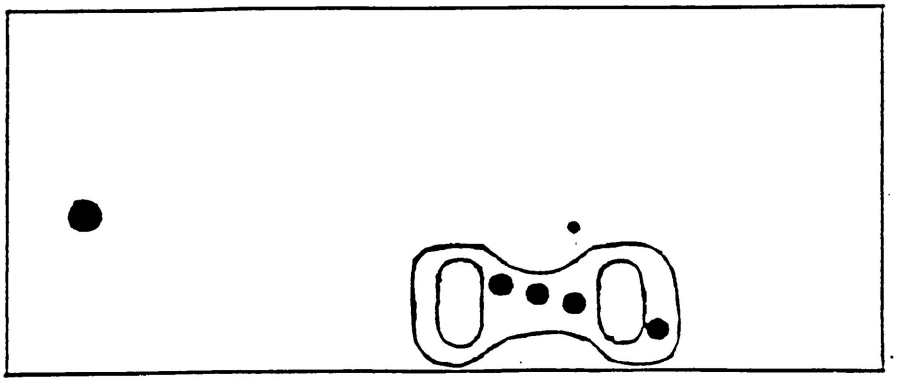
Figure 2. Ball Positions at 6 ft. Distance



Ball Position = Forward in Stance



Ball Position = Mid-Stance



Ball Position = Rear-Stance

Figure 3. Ball Positions at 15 ft. Distance

each putt. Subjects had a choice of three putters corresponding to lengths of 34" (short), 35" (medium) and 36" (long). Subjects took their stance and determined the natural positioning of their hands (the position they felt comfortable with). As they did this they tried holding each of the putters to see which felt most natural for their stance and hand position. All putters were of the two sided design commonly used in mini-putting. A Teitleist 90 compression golf ball was used for trials. SURLYN OR BALATA?

Procedure

The factorial combination of 3 Ball Positions (forward, mid-stance, rear-stance), 2 Points of Aim (eyes over the ball and eyes along the ball-target line) and 2 Distances (6 and 15 feet) results in 12 treatment conditions. Subjects attempted 10 putts from each of the treatment conditions resulting in 120 total attempts. Two blocks of trials made up the total. The two blocks corresponded to each of the two putting distances (D1 = 6 feet, D2 = 15 feet). Ordering of treatments within the two blocks was randomly assigned. Ordering of blocks was counterbalanced between subjects.

Subjects filled out consent forms and were given a briefing sheet notifying them of the time of their testing and of the nature of the study. Any questions subjects had were answered after reading the briefing sheet. Subjects agreed not to practice putting between the time of notification of their selection and the time of their trials.

Twenty minutes prior to the beginning of the experiment, each individual received putting instruction in the form of a videotaped lesson given by the experiment coordinator (an experienced golf instructor). Thus all subjects received the same instruction which included:

1) The Grip:
   A) 4 common grips used by golfers and their differences:
      a) Baseball Grip,
      b) Interlocking Grip,
      c) Overlap Grip, and
      d) Reverse Overlap Grip.
   B) Fundamentals Common to All Grips:
      a) hands facing each other, and
      b) thumbs placed on top of the grip.

2) The Stance:

   A) 3 Common Stance Widths:

      a) Narrow,

      b) Medium, and

      c) Wide.

   B) Foot Placement in the Square Stance:

      Feet are positioned perpendicular to a line running from the ball to the hole.

3) Ball Position - 3 Possible Ball Positions:

   A) Forward in stance,

   B) Mid-Stance, and

   C) Rear-Stance.

4) Eye Position - 2 Possible Eye Positions:

   A) Over the Ball, and

   B) Down the Ball-Target Line.

5) Posture:

   A) 2 Possible Postures:

      a) Upright, and

      b) Crouched or Bent Over.

   B) Stressing the necessity of a comfortable posture.

6) The Putting Stroke (backstroke, contact and follow-through).

Any questions subjects had regarding the video were answered immediately following it's presentation. Subjects then proceeded directly to the putting area to begin their attempts. Since the apparatus was already set up, the experiment coordinator demonstrated to subjects how each trial would proceed. Subjects were shown the 3 different lengths of putters and were told they could choose whichever putter felt most comfortable for them. After trying putters using their stance and hand positions, subjects determined the correct length of putter for them. Since putting is such an individual matter, it was stressed that comfort should be a determining factor in putter selection.

After selecting a putter, each subject demonstrated their version of the grip, stance, posture and stroke. Any necessary corrections were made by the experiment coordinator. Immediately prior to each block of 60 trials subjects took 10 practice shots for the distance corresponding to that block. Practice trials allowed subjects to determine the speed of the putting surface and the force with which to strike each putt. Two experimenters conducted the trials and measurement procedures. Subjects completed each trial

"at their own pace" after the appropriate setup was conducted for each trial.

To achieve appropriate set-up the experimenter positioned the "foot placement mat" for each trial. The ball was placed on its designated spot and the subject took his/her place on the foot placement mat, adjusting his/her grip and stance. The experimenter then placed a "plumb line" directly over the position where the subject was to place his/her eyes. If the trial was an "eyes over the ball" trial, the plumb line was placed directly over the ball. The subject had to position his/her head so that the bridge of the nose was directly over the string from the plumb line. When this was done, the plumb line was removed.

For trials where the eye position was "down the ball-target line", the plumb line was placed on a spot 6" to the right of the ball from the subject's perspective. The experimenter working with the subject determined this eye position by taking the ball position read to him by the other experimenter and using the marks on the foot placement mat as a reference. These marks were placed in 6" increments to allow for mat placement and for plumb line placement

(see Figure 2 and Figure 3). When the head position was set, the plumb line was removed. Prior to trials, subjects were told they could look at the hole before they took their shot but must not move their head position forward, backward or side to side. This requirement was strictly enforced by the experimenters. Thus head position remained constant for each trial.

Additionally, prior to trials, subjects were told they should try to stroke the ball so that it finished directly on top of the simulated hole. It was emphasized that the goal was not to finish long, short, left or right but directly at the hole. After each putted ball, the two experimenters measured it.

Distance in centimeters (cm) was determined using a tape measure and yardstick. The three dots placed on the putting surface at three foot distances from the hole (see Figure 1) and the hole itself were used as reference points for measurement. An X,Y coordinate system was utilized for recording all putts. The X coordinate represented distance from the hole for putts that were short or long. Putts finishing short of the hole were given a negative (-) value and putts finishing long were given a positive (+) value. The Y

coordinate represented distance from the hole for putts that finished to the left or right of the hole. Putts finishing to the left of the hole were given a negative (-) value and putts finishing to the right of the hole were given a positive (+) value.

All putts were measured to the nearest 1/2 centimeter (cm). For putts that hit the hole an "H" for Hit was recorded on the score sheet. A ball was deemed to hit the hole if any part of the ball travelled over any part of the hole as determined by the experiment coordinators.

Results

Hits

Analysis of the target hits revealed main effects for eye position, $F(1,28) = 5.36$, $p = .03$, distance, $F(1,28) = 397.06$, $p < .0001$, and ball position, $F(2,56) = 3.36$, $p = .04$ (See Appendix, Table 1). Significantly more putts were made utilizing the eyes over the ball position (41.9%) compared with the eyes along the ball-target line position (38.6%).

Further, results indicated that there were significantly more putts made from the 6 foot distance (59.8%) than from the 15 foot distance (20.9%). This is consistent with research findings by Aksamit & Husak (1983), Cockerill (1980), Kelliher (1963), and Wannebo & Reeve (1984).

Finally, the post-hoc analysis indicated that the rear-stance ball position (putts made = 37.6%) was significantly less accurate than both the forward-stance ball position (putts made = 41.4%) and the mid-stance ball position (putts made = 41.7%). No other terms reached statistical significance.

X Data

Analysis of error along the X coordinate revealed a main effect of eye position, $F(1,31) = 5.09$, $p = .03$. Error in overshooting the target was significantly greater for the eyes over the ball position (Mean Error = 72.57 cm) compared to the eyes along the ball-target line position (Mean Error = 51.31 cm)(See Figure 4). None of the other main effects or any of the 2 way interactions reached significance for X data (see Appendix, Table 1).

The 3-way interaction of Eye Position X Distance X Ball Position also reached significance, $F(2,62) = 9.16$, $p < .001$.(See Figure 5). Post-hoc analysis revealed that, in general, error was least when the ball was in the rear-stance position regardless of both distance and eye position. However, for the other two ball positions, distance and eye position had opposite effects. Specifically, with the ball in the forward-stance position and putting from the 6 foot distance, error was least for the over the ball eye position. However, the relation was reversed at the longer, 15 foot distance. Alternatively, with the ball in the middle-stance position the entire relation was

reversed, although the difference between the eye positions was not significant at the 15 foot distance.

Y Data

Analysis of the findings along the Y coordinate revealed a main effect for Ball Position, $F(2,62) = 3.72$, $P = .03$ (See Appendix, Table 4). Error to the right of the target was less with the rear-stance ball position (Mean Error = 19.69 cm) than from the forward-stance ball position (Mean Error = 32.74 cm) and less from the forward-stance ball position than from the mid-stance ball position (Mean Error = 56.54 cm)(See Figure 8). The post-hoc analysis confirmed that the difference between all three stance positions was significant. None of the other main effects or any of the interactions reached significance for Y data (See Appendix, Table 4).

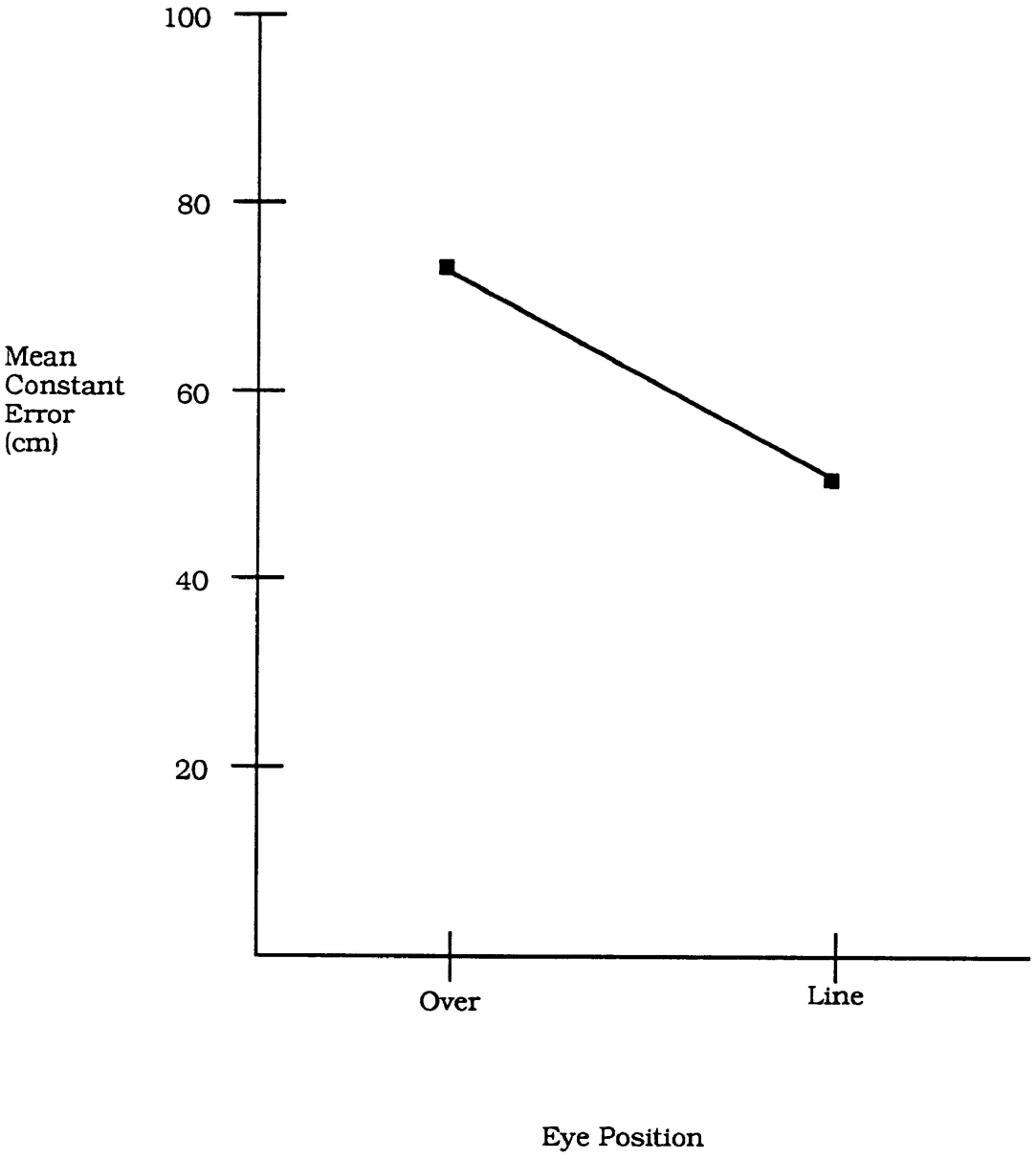


Figure 4. Eye Position (X Data)

Note: The ordinate does not include negative values because all mean data were positive (overshooting of the target).

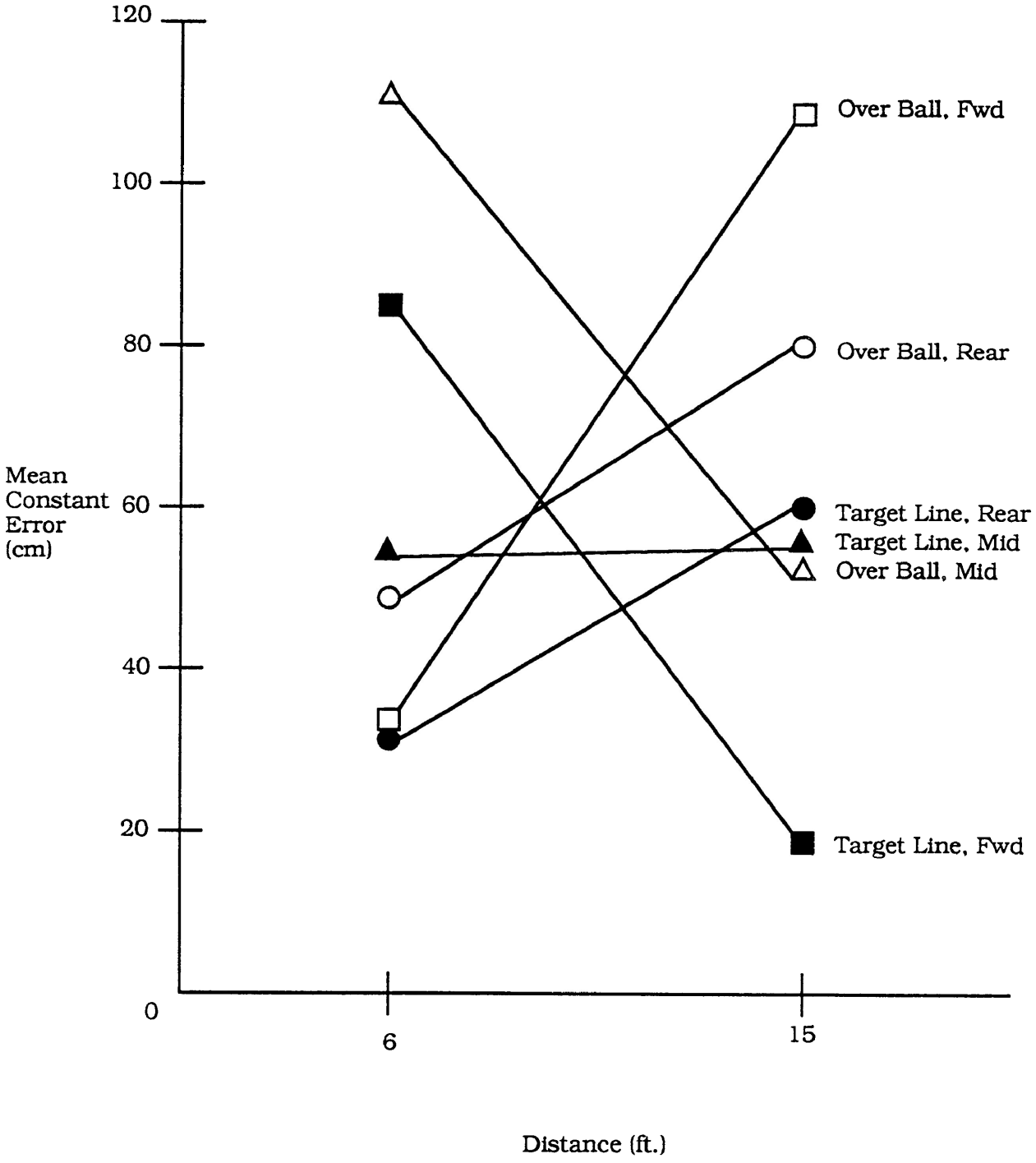


Figure 5. Eye Position X Distance X Ball Position (X Data)

Note: The ordinate does not include negative values because all mean data were positive (overshooting of the target).

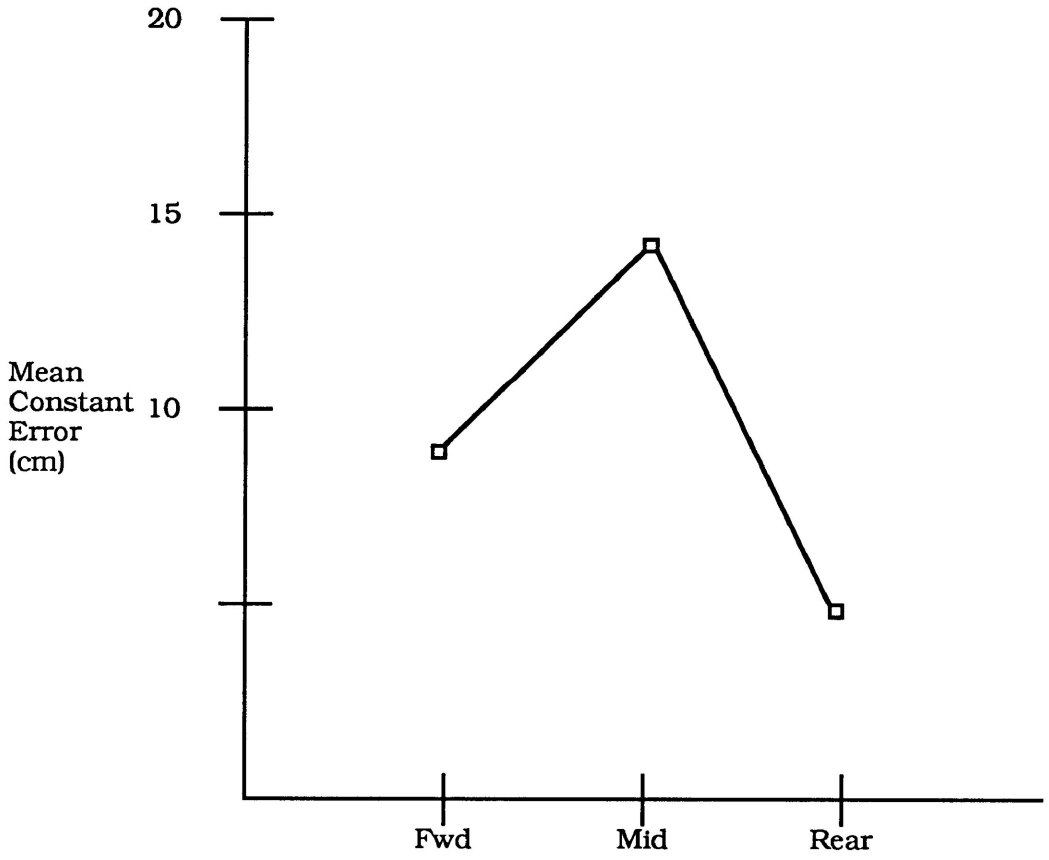


Figure 6. Ball Position (Y Data)

Note: The ordinate does not include negative values because all mean data were positive (to the right of the target).

Discussion

Because this study measured putting on a flat surface, it is important to note that the results may be limited to straight-line putts. This is considered an appropriate place to begin to understand the influence of different putting styles on accuracy. Putts on uneven or sloping surfaces require additional skills which beginning golfers need to acquire.

It is apparent from analysis of the data that the beginning golfers missed significantly more putts than they made (ie. those that hit the target). These misses account for approximately 58 to 62 percent of the putting trials. Thus, the implication is that beginning golfers will be faced with at least one extra putt to achieve their objective of putting the ball into the hole. It is important then, to consider what the results of the missed putts indicate. A golfer who hits a putt that finishes close to the hole stands a greater chance of making the next putt. Since almost twice as many putts missed the target compared to those that hit the target, a logical strategy would be to determine which methods help to increase the accuracy of the missed putts. As well, the small difference in

percentage of putts made between the two eye positions (3.3%) and the two most accurate ball positions (Forward = 41.4 % made, Mid-Stance = 41.7% made) further increases the value of the miss data in determining the most accurate putting method overall used in this study.

This study divided missed putts into two components: misses in terms of the overshooting or undershooting the target (X data) and misses in terms of whether the ball finished left or right of the target (Y data).

Three factors help to explain the results from the present study. These include:

1. View of the Target: The subject's ability to see the target seemed to increase putting accuracy.
2. Stabilization of the Stance: A more stable stance appeared to increase accuracy at the shorter distance (6 foot putts).
3. Optimal Range: There appeared to be an optimal range for putting accuracy for the eyes along the ball-target line position. However, the exact limits of this range were not within the scope of this study.

These factors will be discussed in terms of the X and Y data findings.

View of the Target

Overall, the ball-target line position was found to be significantly more accurate than the eyes over the ball position. It is likely that due to the orientation of the head and eyes, the ball-target line position allows subjects to view the target with little or no head movement compared to the over the ball position. This is probably due to the natural tilt of the head and eyes towards the target when using this orientation and is consistent with findings by Whiting and Cockerill (1972). Theoretically, intermittent vision of the target may cause degradation of the memorial representation of target distance and direction when utilizing the eyes over the ball position. This could lead to a decrease in accuracy when compared with the eyes along the ball-target line position.

At the six foot distance, both eye positions provide a reasonable view of the target. This would explain why the differences in error for the two eye positions for X data (overshooting, undershooting) are less at 6 feet compared to 15 feet. At 15 feet the

difference in error between the two eye positions widens in favour of the eyes along the ball-target line position. Results for Y Data (left,right) were similar (with the exception of the mid-stance position - possibly the result of lack of stance stabilization). As distance increases, the natural orientation of the head and eyes tends to impede the view of the target for the eyes over the ball position. Thus, with only intermittent visual input of the target, the subject may have to rely on a memorial representation of the target position that degrades rapidly. Further, research will have to consider the nature and the time course of this representation.

Stabilization of the Stance

Only two Eye X Ball positions used in the present study (out of a possible total of six) positioned the body in such a way that the weight is centred midway between the feet (ball-target line, forward stance and over the ball, mid-stance). In all other positions the body had to lean toward either the forward or rear foot. In general, at the 6 foot distance, Eye X Ball positions in which the body was leaning either toward the forward or the rear foot showed a decrease in error

when compared to positions where the body weight was centred between the feet. For X data this was true in every instance. For Y data the one exception was the ball-target line, forward stance position which differed little in error from the over the ball, forward position. It is possible that leaning in one direction (either forward or to the rear of the stance) may have a stabilizing effect on the putter's body. Theoretically, less moving body parts should result in a more compact and likely a more accurate stroke.

At the 15 foot distance, body lean does not appear to affect accuracy for either X or Y data. It is likely at this distance that the view of the target is a greater factor in decreasing error than the benefit of stance stabilization.

Optimal Range

The fact that both X and Y data error decreased as a function of distance for the eyes along the ball-target line position suggests that there is an optimal range for accuracy for this eye position when considering putts that missed the target. Since error decreased at the 15 foot distance, it is probable that the 15 foot distance falls within this optimal range. However, without further investigation it is impossible

to determine exactly which distances fall within this range.

The rear-stance position was the most accurate from the six foot distance. It is likely that from this position the stance was more stable. The fact that the over the ball, rear-stance position was the most accurate from 6 feet may suggest that the right (bottom) hand played a pivotal role in the guidance of the stroke. In this body position the right hand is most likely to be returned squarely to the ball at the bottom of the stroke's arc since it begins the stroke aligned squarely with the target and is hanging straight down. This would facilitate a pendulum type motion for the stroke which theoretically should increase accuracy. Touring professionals who use the extra long putters strive for this effect with the left or top hand essentially acting as a fulcrum and the bottom or right hand acting as a guide.

Conclusions

The purpose of this study was to:

1) determine the influence on putting accuracy due to: a) the position of the eyes relative to the ball, and

b) the position of the ball relative to the stance, and

2) determine the influence of distance in determining the most effective putting style.

The following conclusions were made concerning the present study:

1. The forward ball position appears to be the best overall position for increasing putting accuracy.

2. On shorter putts the eyes should be positioned over the ball.

3. On longer putts the eyes should be positioned along the ball-target line.

Recommendations

The following recommendations are based upon the conclusions and a critical analysis of the findings of the current study:

Beginning golfers should:

1. position the ball forward in the stance,
2. position their eyes over the ball on shorter putts,
3. position their eyes along the ball-target line on longer putts.

Future studies of interest would include:

1. an attempt to determine the distances that make up the optimal range for the eyes along the ball-target line position,
2. an assessment of the the accuracy of a putted ball utilizing various time intervals between viewing the target and the actual putt to determine the effect of target memory degradation,
3. determination of the role of the stance in the accuracy of a putted ball, specifically the direction of the stance (ie. either square, open or closed),
4. an extension of the present study to include putting trials on sloping surfaces of varying degrees,

). a replication of the current study to see if the results are similar for children and adolescents (the ages of subjects for the current study ranged from 19 to 54 years).

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Appendix A

Analysis of Variance (Hit Data)

Appendix A

Table 1

Analysis of Variance (Hit Data)

Source	SS	DF	MS	F	P
Group	11.84	3	3.95	.70	.56
Error	157.03	28	5.61		
Eye	10.34	1	10.34	5.36	.03*
Error	53.99	28	1.93		
Distance	1468.75	1	1468.75	397.06	<.0001*
Error	103.57	28	3.70		
Ball	13.61	2	6.80	3.36	.04*
Error	113.38	56	2.02		
Group X Eye	1.42	3	.47	.25	.86
Error	53.99	28	1.93		
Group X Distance	6.09	3	2.03	.55	.66
Error	103.57	28	3.70		
Group X Ball	25.18	6	4.20	2.07	.07
Error	113.38	56	2.02		
Group X Eye X Distance	4.01	3	1.34	.48	.70
Error	78.11	28	2.79		
Group X Distance X Ball	6.93	6	1.16	6.40	.70
Error	107.71	56	1.82		
Group X Eye X Ball	7.76	6	1.29	.81	.57
Error	89.29	56	1.59		
Group X Eye X Distance X Ball	16.42	6	2.74	1.00	.43
Error	152.54	56	2.72		
Eye X Distance	1.63	1	1.13	.58	.64
Error	78.11	28	2.79		
Distance X Ball	1.19	2	.60	.33	.73
Error	101.71	56	1.82		

Appendix B

Analysis of Variance (X Data)

Appendix B

Table 2

Analysis of Variance Summary Table (X Data)

SOURCE	SS	MS	DF	_	_
Subjects	115153.32		31		
Eye Position	43357.44	43357.44	1	5.09	.03
Error	264169.92	8521.61	31		
Distance	257.82	257.82	1	.06	
Error	143544.25	4630.46	31		
Eye x Dist	17302.81	17302.81	1	2.86	.10
Error	187495.98	6048.26	31		
Ball Position	11638.63	5819.32	2	.82	
Error	442837.46	7142.54	62		
Eye x Ball	948.91	474.46	2	.07	
Error	420606.38	6783.97	62		
Dist x Ball	55056.02	27528.01	2	2.52	.09
Error	676910.83	10917.92	62		
EyeXDistXBall	160826.83	80413.42	2	9.16	<.001
Error	544198.52	8777.40	62		
Total	3084305.11		383		
Residual	2679763.33		341		

Appendix C

Cell Means (cm) and Standard Deviations for X Data

Appendix C

Table 3

Cell Means (cm) and Standard Deviations for X Data

Position	Mean Error	SD
Over/6/Fwd	35.94	60.19
Over/6/Mid	110.78	119.53
Over/6/Rear	48.41	82.08
Over/15/Fwd	108.89	105.89
Over/15/Mid	51.86	99.61
Over/15/Rear	79.56	84.72
Line/6/Fwd	83.08	105.32
Line/6/Mid	55.72	97.46
Line/6/Rear	32.77	57.60
Line/15/Fwd	19.33	45.51
Line/15/Mid	56.59	65.27
Line/15/Rear	60.36	83.42

Appendix D

Analysis of Variance (Y Data)

Appendix D

Table 4

Analysis of Variance Summary Table (Y-Data)

SOURCE	SS	MS	DF	-	
Subjects	14655.50		31		
Eye Position	18.16	18.16	1	.03	
Error	22339.16	720.62	31		
Distance	16.46	16.46	1	.02	
Error	22240.27	717.43	31		
Eye x Dist	108.91	108.91	1	.15	
Error	23328.41	752.53	31		
Ball Position	5523.48	2761.70	2	3.72	.03
Error	46029.15	742.41	62		
Eye x Ball	2230.29	1115.10	2	1.36	.26
Error	50822.84	819.72	62		
Dist x Ball	499.32	249.66	2	.26	
Error	59885.39	965.89	62		
EyeXDistXBall	2698.93	1349.47	2	1.87	.16
Error	44839.44	723.22	62		
TOTAL	295235.69		383		
Residual	269484.65		341		

Appendix E

Cell Means (cm) and Standard Deviations for Y Data

Appendix E

Table 5

Cell Mean (cm) and Standard Deviations for Y Data

Position	Mean Error	SD
Over/6/Fwd	6.72	22.71
Over/6/Mid	17.50	31.44
Over/6/Rear	1.41	24.04
Over/15/Fwd	16.72	34.41
Over/15/Mid	9.14	19.61
Over/15/Rear	4.20	33.51
Line/6/Fwd	6.42	27.36
Line/6/Mid	13.03	27.55
Line/6/Rear	8.06	33.78
Line/15/Fwd	2.88	20.23
Line/15/Mid	16.67	18.97
Line/15/Rear	6.02	31.24

Appendix F

Putting Experiment Briefing Sheet/Consent Form

Appendix F

Putting Experiment Briefing Sheet/Consent Form

The experiment you are about to take part in is part of a university study in the field of Physical Education. The study focuses on the skill of putting in the game of golf. You will view a short instructional video, followed by some personal instruction, a few practice trials and finally the trials themselves. During the experiment, the experiment supervisor will ask you to make certain physical changes in the way you place yourself in relation to the ball. In addition, the position of the ball itself will be placed randomly in different positions. The experiment supervisor will check to see that these changes have been made before each putt. The position of your feet will remain constant for each putt. You will be shown exactly where to place your feet. After each putt the supervisor will measure where the ball finished and log the result on the trial log sheet. Putts will be taken from two distances: six feet and fifteen feet. Sixty putts will be taken from each distance. Practice putts will be allowed before the trials at each distance.

For each and every putt you should concentrate on the following:

1) Try to aim the putter face directly at the hole before each putt.
2) Stroke the ball with the putter so that it goes straight at the hole and stops at exactly the same distance from you as the hole. You have to determine how hard to hit the putt.

../2

You will not be told during the experiment whether you are putting "well" or "poor". In fact, for the purposes of the study, it doesn't matter. You as an individual are not being measured, it is the style of putting that is being tested. Your name and identity will not be mentioned in the study. You will simply be known as one of the 32 subjects or as Subject number one, two, etc. However, for purposes of proof of research, you will be asked for your name, age, sex, whether you are a beginner in golf and whether you work in Canadian Forces Base Borden.

I understand all of the above and consent to take part in this study and give my consent to the experiment supervisor to publish any results or information resulting from my participation in this study. I agree to not practice putting between the time of notification of selection for this study and the time of trials themselves.

Signed _____ Age _____ Sex? M

Beginner in golf? Yes No

Work in CFB Borden? Yes No Date Signed _____

The Date of my testing is _____.

The Time of my testing is _____.

The location is the CFSAL building (Bldg T-145), rear entrance.

Vita Auctoris

Name:	Stephen George King
Place of Birth:	Windsor, Ontario, Canada
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Education:	Bachelor of Human Kinetics University of Windsor, Windsor, Ontario 1980-1985
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