THE ROLE OF VISUAL & VERBAL FEEDBACK IN GOLF PUTTING ACCURACY

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Abstract

The purpose of the present investigation was to determine the role of visual and verbal feedback on golf putting accuracy. The putting accuracy of 12, visually-normal, inexperienced golfers (range 23-66 years, mean=42 years) was assessed for small (3cm) and large (12cm) targets located 6 feet away. After a brief practice interval, subjects performed the task: under either normal viewing conditions ("control"); behind a large cardboard baffle that eliminated most of their central and peripheral visual field ("no visual or verbal feedback"); or behind the same baffle but with verbal knowledge of putt accuracy ("verbal feedback only"). There was no significant difference between any condition for both the 3cm and 12cm target. The difference in putting percentage accuracy between the three conditions ranged from 2.1%-4.6% for the 3cm target and from 0.4%-2.9% for the 12cm target. Comparison of the first 10 shots to the last 10 shots for each condition revealed no significant differences in putting performance. These findings are consistent with earlier studies demonstrating a reduced reliance on visual feedback for certain simple, repetitive, and fixed sensorimotor activities. In such tasks, visual information appears to be of less importance, once the proper force-distance paradigm has been incorporated into motor memory. Further, motor memory does not appear to dissipate with the withdrawal of visual feedback, at least in the short term.

Key Words

distance judgment, golf putting, motor learning, verbal feedback, visual feedback, visual field

INTRODUCTION

Golf is a popular pastime for people of all ages. The subtle intricacies of the game mandate extensive practice to become successful. Perhaps the most important aspect of any golfer's game is one's ability to successfully execute relatively close shots on and around the green. Wiren demonstrated this fact when he wrote that both amateur and professional golfers alike expend nearly 50% of their strokes on putting.[1]

The general role of vision in athletic performance has been a subject of study for many years. For example, Vickers observed the fixation patterns of elite basketball players making free throws.[2] When compared to those approaching expertise, elite players were found to spend significantly more time fixating the target (i.e., basket) before shot initiation and significantly less time fixating it during the actual shooting sequence. The average free throw shot duration (the interval between upward motion of the ball and release of the ball from the fingers) of 450ms and the average visual reaction time of 200ms. On this basis it was reasoned that vision was potentially a liability for elite athletes who presumably have the proper force-distance calibration embedded in their motor memory.[3] Since the reaction time (200ms) is less than the shot duration (450ms), if vision were not suppressed, and a visual stimulus suddenly appeared, it has the potential to interfere with the actual free throw motion, i.e. the motor task. As such, it was speculated these athletes benefited from apparent transient suppression of vision during the actual shot initiation and completion.

Applegate and Applegate investigated the role of inducing mild to moderate amounts of spherical retinal defocus on basketball shooting.[4] Amateur athletes were optically blurred to visual acuity levels ranging from 20/40 to 20/250, and their performance was recorded. No significant difference was found in shot performance for any lens condition. It was argued that subjects rapidly compensated for the blur and were able to achieve a similar level of performance as the no-lens control condition. However, no mechanism for this compensation was proposed. Mann et al demonstrated that optically-induced blur of 1.00 to 2.00D had a minimal impact on cricket batting performance.[5] It was not until the 3.00D level of blur that performance was found to decline. Similarly, Bulson et al examined the role of both spherical and astigmatic retinal defocus on golf putting performance, as well as related eye, head, and putter movements.[6] They were recorded objectively, for targets of varying sizes. Mild to moderate amounts of retinal defocus were found to have a minimal effect on all parameters. It was not until a very high level of defocus was introduced (+10.00 D) that putting performance began to decline noticeably. Thus, a number of sports vision related studies have demonstrated a lower reliance on visual information than might be expected during sports performance.

One proposed mechanism for the reduced role of vision in sports is motor learning.[3,7,8] Halsband described motor learning as the ability to perform a learned task in a manner that is "automatic and implicit" as compared to the "conscious and explicit" control seen before the task has been incorporated into motor memory.[9] A number of recent studies have proposed motor memory as the mechanism for performance of tasks under conditions of reduced visual feedback. For example, Sasaki et al studied the role of vision in monkeys learning to use forceps to pick up food.[10] After learning to use the forceps under manual human guidance, monkeys initially reached for the food using the forceps without shifting gaze to look at it. It was only after making contact with the food that the monkeys then shifted their gaze directly to the targeted food. After numerous repetitions of the task, however, monkeys began shifting their gaze towards the food prior to contact of the forceps to the food, and accuracy improved significantly. Interestingly, monkeys appeared to actively avoid employing visual information in the early stages of the previously learned task, similar to that found by Vickers for the elite basketball player.[2] Franklin et al also concluded that visual feedback was not essential in a motor learning task.[11] The study demonstrated that vision was not necessary for adaptation to either stable or unstable dynamics during a hand-reaching task. Adaptation to both dynamics as measured via endpoint stiffness and force endpoint was equal between subjects who received visual feedback and those who did not. Although the endpoints were the same between subjects with and without visual feedback, those with the feedback demonstrated less variability. Thus, as with monkeys, visual feedback is not essential as long as the task has been incorporated into motor memory; however, visual feedback is perhaps important in achieving greater accuracy for more detailed tasks.

The primary purpose of the present investigation was to determine the role of visual and verbal feedback on golf putting accuracy. A secondary purpose was to assess for the dissipation of motor memory immediately following the withdrawal of visual feedback.

METHODS
Subjects
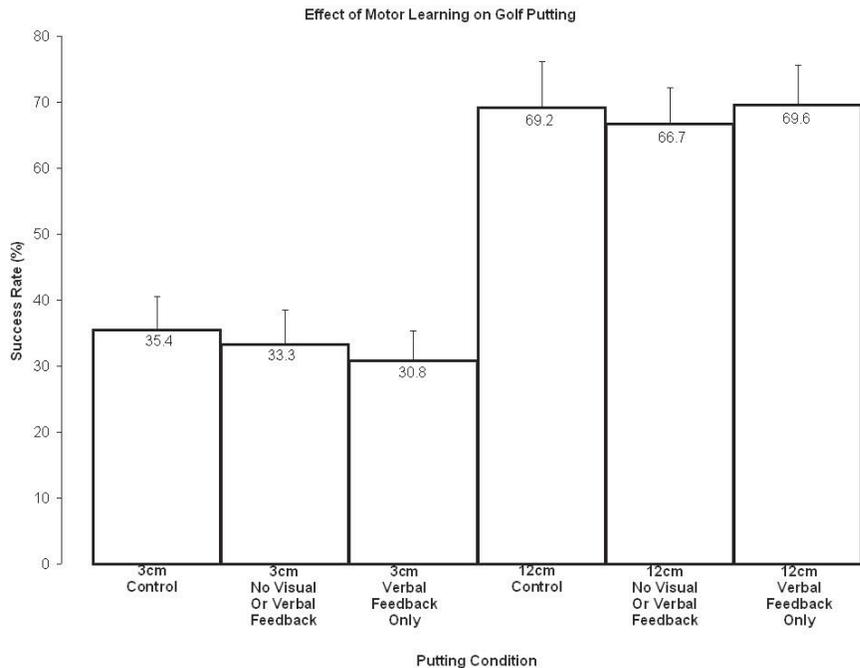Twelve novice adult golfers ranging in age from 23-66 years (mean=42 years)

Figure 1. Successful putts (%) for each condition. The number at the top of each graph represents the mean. Plotted is the mean +1 SEM.

were recruited from the SUNY State College of Optometry (students and faculty). Eight were male, and four were female. Each reported having normal binocular vision, were free from any ocular or neurological disease, and were visually asymptomatic. None were taking any medications that could adversely affect either the oculomotor system or general motor control. All were fully corrected in each eye with their distance refractive prescription through the use of either spectacles or contact lenses, if correction was needed. All subjects signed consent forms and the study was approved by the College's Institutional Review Board.

Putting Green Design
A mock putting green composed of artificial turf 3.45m long and 1.80m wide was used to simulate an actual putting surface.[6] The target area was comprised of a painted circle the size of a standard computer CD, with the 3cm diameter center hole approximating the size of a standard golf ball (4.4cm), and the entire disc itself (12cm) approximating the standard cup diameter (10.5cm) at a distance of 1.83m (6 feet). The luminance values of the ball, the putting green, and the target were 42cd/m,[2] 1.6cd/m,[2] and 2.5cd/m,[2] respectively, which approximated actual golf course conditions on a cloudy day. The contrast of the ball and the target on the putting green was 93% and 22%, re-

spectively. All trials were conducted under standard room illumination.

Procedure
The experiment consisted of four parts. First, subjects executed 20 practice putts to the target. Second, following this practice session, subjects executed 20 consecutive putts to the same target under normal full-field viewing conditions ("control" condition). Third, following the control condition, a 100cm by 80cm cardboard baffle located 1.5m above the floor was placed in front of the subject to obstruct his or her view of the target. With the subject placed at a distance of 30cm from the baffle, the visual field was restricted approximately 110 degrees horizontally and 95 degrees vertically. The subject could only see the ball and approximately 1 foot in front of it. Subjects then made 20 putts to the same target. During these 20 attempts, no visual or verbal feedback was available to the subject ("no visual or verbal feedback" condition). In the fourth and last phase of the experiment, the baffle remained in place, and subjects were asked to execute 20 additional putts. However, now they were provided verbal feedback regarding their performance ("verbal feedback only" condition). If the ball made contact with any portion of the target, the examiner responded "contact" to the subject. If the ball missed the target to the right or left, the examiner responded, "missed to the right" or "missed to the left," respectively. No magnitude error information

was given. The percentage of completed putts for both the small and large target was computed for all test conditions.

The putting performance was scored as correct for the small target if at least half the ball crossed the 3cm center portion of the painted target. Likewise, the large target was scored as correct if the ball passed over at least half of the painted target but did not cross the 3cm target by half or greater.

RESULTS

The group findings for both the 3cm and 12cm targets are presented in Figure 1. A two-way ANOVA was performed for the factors of target size (3cm and 12cm) and viewing condition ("control," "no visual or verbal feedback" and "verbal feedback only"). The analysis was significant for target size [F $(1, 11)$=789, $p<0.0001$], but not viewing condition [F$(2, 22)$=1.358, $p=0.2644$]. The post-hoc Bonferroni analysis revealed significant performance differences ($p<0.001$ for all conditions) between the 3cm and 12cm target. The difference in putting percentage accuracy between the "control" and the "no visual or verbal feedback" for the 3cm and 12cm target was 2.1% and 2.5%, respectively. The difference between the "control" and the "verbal feedback" for the 3cm and the 12cm target was 4.6% and 0.4%, respectively. The last comparison of the "no visual/verbal feedback" to the "verbal feedback" for the 3cm and 12cm target was 2.5% and 2.9%, respectively. Figure 1 compares each situation and target size. Differences in putting accuracy of 33.8%, 33.5%, and 38.8% were found when comparing the 3cm target to the 12cm target for each of the same three conditions, respectively, with performance always being better for the larger target.

Additionally, comparison of the first 10 shots to the last 10 shots for each condition was conducted for both the 3cm and 12cm targets. A t-test revealed no significant differences in putting performance [$t(22)>0.30$, $p>0.05$ for all conditions].

DISCUSSION

The results of the present study suggest a more limited role for visual feedback in certain situations than perhaps might otherwise be predicted intuitively. However, these findings are in agreement with previous studies demonstrating a relatively reduced reliance on visual feedback under specific task conditions. For example, some of these studies have demonstrated

that low levels of retinal defocus and related blur have a minimal impact on performance for a range of athletic activities as described earlier.[4-6] They reasoned that the addition of blur may actually be beneficial by initially providing clues on the nature of the movement. Although no mechanism was proposed, Mann et al inferred that the simple and static nature of the task allowed for reduced reliance on vision.[5] Another proposed explanation by Mann et al was the role of the magnocellular pathway in the task, which is responsible for detecting motion, with its inherent relative insensitivity to blur.[12]

It is possible that in certain fixed and repetitive situations, acute vision is not necessary during the actual motor sequence from the initial upward motion of the ball to the release of the ball from the fingertips. An earlier study by Vickers investigated the role of vision in elite and near-elite basketball athletes shooting free throws.[2] They objectively determined that overall gaze patterns between the elite and near-elite athletes differed significantly. Elite athletes tended to have longer final fixations and "quiet eye" periods. The time interval between the final fixations to the initiation of the shot sequences is longer. However, while their fixation itself was longer prior to the execution of the motor task, elite athletes demonstrated an earlier fixation offset and increased frequency of blinking during the actual motion as compared to near-elite athletes. These results suggest that vision is important in gathering information about the task environment prior to the motor sequence, but becomes less important as the sequence is initiated. Given the average free throw shot duration of 450ms, it was reasoned that visual input with its average reaction time of 180-200ms could interfere with the latter phases of the ingrained motor sequence. As such, Vickers inferred that vision actually is a liability for elite athletes performing a repetitive motor sequence, and hence it is perceptually suppressed as the sequence is initiated.[2] Thus, vision may be of lesser importance for simple and static activities than would be anticipated, at least for a portion of the motor activity.

If vision is indeed a liability in performing certain basic repetitive tasks, there must be an underlying mechanism that establishes the proper neuromuscular force-distance paradigm for the fixed task. Wolpert et al defined motor learning as the establishment of an internal

model that represents the exact matching between perceived sensory and motor information.[13] Halsband later described the three phases of motor learning.[9] In the initial phase, performance is slow and under close sensory guidance. The intermediate phase is characterized by an increase in speed, as well as reduced reliance on sensory information, such as vision. It is at this phase where the sensorimotor map, that is the force-distance paradigm, is being established in short-term motor memory. Repetition further reinforces this map, until it becomes ingrained into long-term motor memory. Incorporation into long-term motor memory characterizes the advanced phase, in which performance becomes automatic, i.e., reflexive, and hence requires minimal sensory input. While it is unclear exactly how many repetitions a novice golfer would require to attain each of these phases, the reduced reliance on visual information suggests that subjects in the present study had attained at least the intermediate motor memory stage. Further, once this stage of motor memory was attained, it did not appear to diminish with withdrawal of visual feedback, at least in the short term (i.e., approximately 5 minutes) under the conditions of the present experiment.

Recent studies have employed motor memory to explain the reduced dependence on visual input during repetitive tasks. Sasaki et al observed that monkeys learning to use forceps to grasp food initially shifted their gaze away from the food during the grasping sequence, similar to that found by Vickers during basketball free throws.[2,10] As the task was repeated, the monkeys became progressively more adept at grasping the food, but persisted in denying themselves visual information. This stage was described as the organization of numerous motor and non-visual sensory signals to establish a new sensorimotor map where proprioceptive feedback, combined with knowledge of the outcome, was of more importance than the visual information per se. The authors postulated that the initial step in defining the appropriate sensorimotor map was dependent on body movement, that is proprioceptive and kinesthetic cues versus visual cues. This theory is supported by the observation that the monkeys did not begin to incorporate visual information until they had become proficient at the task without vision. Sasaki et al reasoned that in the early stages of motor learning, the additional sensory input further com-

plicated an already complex task by disturbing the monkeys' concentration and attention.[10] Once the proper sensorimotor map was in place, however, and the movements had become more automatic and reflexive, vision served to improve efficiency of the task.

Lastly, another important finding of the present study was that verbal feedback had no significant impact on performance. It is well established that adults perform better under conditions of reduced knowledge of results, which is consistent with the present findings.[14-17] Similar to visual feedback, verbal feedback likely served as more of a distraction and complication, rather than an asset to the putting task,once the proper sensorimotor map was in place. For this reason, it is somewhat surprising that the introduction of verbal feedback did not degrade performance in the present experiment. It is possible that the way in which the verbal feedback was provided (after each putt was completed) did not alter subjects' ingrained sensorimotor map to any significant degree. It would be interesting to conduct a similar study using auditory feedback of the eyes, hands, and/or putter trajectory during the actual motor sequence to assess the impact of such motor-based feedback during the golf putting task.

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