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Enhanced or diminished expectancies in golf putting – Which actually affects performance?

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ABSTRACT

Objective: To examine whether performance expectancies enhance or diminish the learning of a putting task in golf. More specifically, our aim was to replicate a previous study (Palmer, Chiviacowsky, & Wulf, 2016), but to add a control group, in order to more accurately assess whether a large circle around the target enhances putting performance and whether a small circle diminishes it.
Design: Laboratory experimental design with three groups: (a) a large-circle group (LCG), (b) a small-circle group (SCG), and (c) a control group (no circle around the target; CG).
Method: Participants were asked to perform a putting task aimed at either a target surrounded by a large circle (14 cm in diameter) or a small circle (7 cm), or at a target with no surrounding circle. Participants completed a pre-test of five putting trials, followed by five blocks of 10 putting trials each. Two days later they performed retention and transfer tests consisting of 12 putting trials each.
Results: Absolute error was significantly smaller in the LCG than in the SCG or CG in the transfer task.
Conclusion: Putting performance was found to be facilitated by enhanced expectancies.

1. Introduction

Motor skill learning can be improved when learners' performance expectancies are enhanced (Wulf & Lewthwaite, 2016). Such performance expectancies can be enhanced by visual illusions (Chauvel, Wulf, & Maquestiaux, 2015; Witt, Linkenauger, & Proffitt, 2012), positive feedback (Stoate, Wulf, & Lewthwaite, 2012), social-comparative feedback (Lewthwaite & Wulf, 2010), bandwidth feedback (Agethen & Krause, 2016; Sherwood, 1988), feedback after "good" rather than "bad" trials of a certain task (Badami, VaezMousavi, Wulf, & Namazizadeh, 2012; Chiviacowsky & Wulf, 2007; Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki, 2012), as well as by relatively easy criteria for good performance (Trempe, Sabourin, & Proteau, 2012). These effects are consistent with the concept of psychological suggestion (a process by which an individual guides the thoughts, feelings, or patterns of behavior of another individual) and its influence on the way individuals think and behave (Michael, Garry, & Kirsch, 2012).

One theory that can explain the benefits of enhanced expectancies through psychological suggestion is the response expectancy theory (Kirsch, 1997). Response expectancies refer to "the anticipation of one's automatic reactions to various situations and behaviors" (Kirsch, 1997, p. 69), and they can be a product of suggestion. Due to these response expectancies, one can automatically change his/her behavior in accordance with the expectancies (Kirsch & Lynn, 1999). For example, if one expects to be successful, his/her behavior can change in a way that will indeed lead to success. In the case of putting in golf, such behaviors can include better focus of attention, more careful and longer preparation before performing the putt (including more precise slope assessment), and maintaining optimal putting biomechanics.

More recently, a novel theory of motor learning – Optimizing Performance Through Intrinsic Motivation and Attention for Learning (OPTIMAL theory) – was proposed (Wulf & Lewthwaite, 2016). The OPTIMAL theory provides a number of possible underlying mechanisms for the benefit of enhanced expectancies. Expectancies for success can (a) increase positive affect and self-efficacy; (b) improve the preparation for task performance; (c) influence both working memory and long-term memory, and bias them towards the expected stimuli; and (d) influence outcome expectations and prediction of external rewards. The abovementioned mechanisms suggest that expectations for good performance may "prepare the mover for successful movement through diverse effects at cognitive, motivational, neurophysiological, and neuromuscular levels – ensuring that goals are effectively coupled with desired actions" (Wulf & Lewthwaite, 2016, p. 1390).

In a study on enhanced expectancies in golf putting (Palmer, Chiviacowsky, & Wulf, 2016), novice participants were divided into

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two groups. Two circles (7 cm in diameter and 14 cm in diameter) surrounded a 2 × 2 cm target. Participants in one group were told that landing the ball inside the small circle was considered a good performance, while participants in the second group were told that landing the ball inside the large circle was considered a good performance. The findings of this study showed that the participants who were told that landing the ball in the large circle was considered a good performance performed better during practice and in both the retention and transfer tests than those who were told that landing the ball in the small circle was considered good performance. This suggests that allowing participants to be more successful in practice can improve later performance.

However, the study by Palmer et al. (2016) did not include a control group, and therefore it is not clear whether the large circle around the target led to enhanced performance in the retention and transfer phases (enhanced expectancies), or that the small circle around the target led to a decline in performance (diminished expectancies). Indeed, in another study on enhanced expectancies in an anticipation timing task (Chiviacowsky, Wulf, & Lewthwaite, 2012), participants were divided into three groups. The participants in one group were told that a relatively large error (30 msec) was considered to be a good performance, the participants in the second group were told that a small error (4 msec) was considered to be a good performance, and those in a control group did not receive any information regarding what was considered to be a good performance. The results of this study showed that both the large error group and the control group outperformed the small error group, and therefore according to this study it was diminished expectancies that hindered performance, as the enhanced expectancy group's performance was similar to that of the control group. As Wulf and Lewthwaite (2016) proposed, just as enhanced expectations can facilitate performance, low (or diminished) expectations can lead to negative affect, anxiety, and task-incompatible concerns, which in turn can reduce task concentration and commitment.

Since a control group was not included in Palmer et al.'s (2016) study, the purpose of the current study was twofold: (a) to replicate Palmer et al.'s (2016) study on putting in golf, and (b) to add a control condition with no circle around the target, in order to differentiate between enhanced or diminished expectancies. As our study was mainly a replication study, and despite the possibility that diminished rather than enhanced expectancies will affect performance, we assumed that the participants practicing with the presence of a large circle around the target would perform better than those practicing with of a small circle or those practicing without a circle.

2. Method

2.1. Participants

Forty-five male physical education students with no golfing experience were randomly assigned to one of three experimental groups: (a) a large-circle group (LCG), (b) a small-circle group (SCG), and (c) a control group (no circle around the target; CG). Randomization was enabled by using a custom program written in Python 3.6 (Python Software Foundation, www.python.org). Participants were naïve to the purpose of the study, and signed an informed consent form prior to participation. The study was approved by the ethics committee of The Academic College at Wingate.

2.2. Apparatus and task

Participants were asked to putt standard golf balls (diameter = 42.67 mm; mass = 45.93 g) to a small target (a 1 cm × 1 cm circle) on a level artificial-turf indoor green (400 × 200 cm), from a distance of 150 cm. For the LCG a large circle (14 cm in diameter) surrounded the target, for the SCG a small circle (7 cm) surrounded the target, and for the CG no circle surrounded the target. The circles were made of white cardboard and were taped to the green's surface. The cardboard was thin and narrow, and did not affect the trajectory or the speed of the golf balls. Participants were instructed to putt the ball so that it would stop as close to the target as possible. Putting accuracy was measured as the distance between the center of the target and the edge of the ball. If a ball contacted the rear border of the putting green, the maximum measurable deviation of 100 cm was recorded. The transfer task was the same putting task but from a distance of 180 cm.

2.3. Procedure

After signing an informed consent form, each participant completed a pre-test of five putting trials without surrounding circles. Then, according to their group assignment, participants performed five blocks of 10 putting trials. The CG putted without the presence of a surrounding circle, the LCG putted with the large circle surrounding the target, and the SCG putted with the small circle surrounding the target. This setup was different from that of Palmer et al. (2016), where both circles were placed on the green at the same time. The setup in the current study was utilized in order to prevent the participants from receiving intrinsic feedback from the circle that was unrelated to the instructions given. Participants in both the LCG and SCG were told that if the ball ended up resting within the circle, the trial was considered successful. In all three groups, after each trial the deviation from the target was measured and was then provided as feedback (in addition to the intrinsic visual feedback) to the participants. Two days later, the participants performed a retention test and a transfer test. Each test consisted of one block of 12 putting trials with no surrounding circles.

2.4. Dependent variables and data analysis

Two dependent variables were measured across the five pre-test trials, the 10 trials for each block in the acquisition phase, the 12 trials of the retention test, and the 12 trials of the transfer test: (a) absolute error (AE) – the average absolute deviation of a set of scores from a target value; a measure of overall error (Schmidt, Lee, Winstein, Wulf, & Zelaznik, 2018), and (b) the number of balls coming to rest in the circle.

A two-way analysis of variance (ANOVA, 3 Groups x 5 Trial Blocks) with repeated measures on the block factor was used to assess the data from the acquisition phase. Retention and transfer data were analyzed separately using analysis of covariance (ANCOVA), with the pre-test performance as the covariate. Statistical level of significance for all analyses was set at $p < .05$, and effect sizes were calculated as partial η^2 (η_p^2). All analyses were conducted using SPSS Statistics version 25 (IBM, United States) and R (R Core Team, 2013).

3. Results

Means and standard errors of AE across acquisition, retention, and transfer are presented in Figure 1.

3.1. AE across acquisition trial blocks

A two-way ANOVA (Group X Trial Block) with repeated measures on the Block factor revealed a main effect for block, $F(4, 168) = 5.76$, $p < .001$, $\eta_p^2 = .12$. AE in Trial Block 5 (24.78 cm) was lower than Trial Blocks 1, 2, and 3 (30.14, 29.14, and 28.47 cm, respectively). AE in Trial Block 4 (25.84 cm) was lower than Trial Blocks 1 and 2. The Group effect, $F(2, 42) = 0.51$, $p = .61$, $\eta_p^2 = .02$, and the interaction between Group and Block, $F(2, 42) = 0.51$, $p = .85$, $\eta_p^2 = .02$, were not found to be significant.

3.2. AE during retention and transfer

For the retention test, a one-way ANCOVA with AE of the pre-test as the covariate revealed no significant difference between groups, $F(2,$

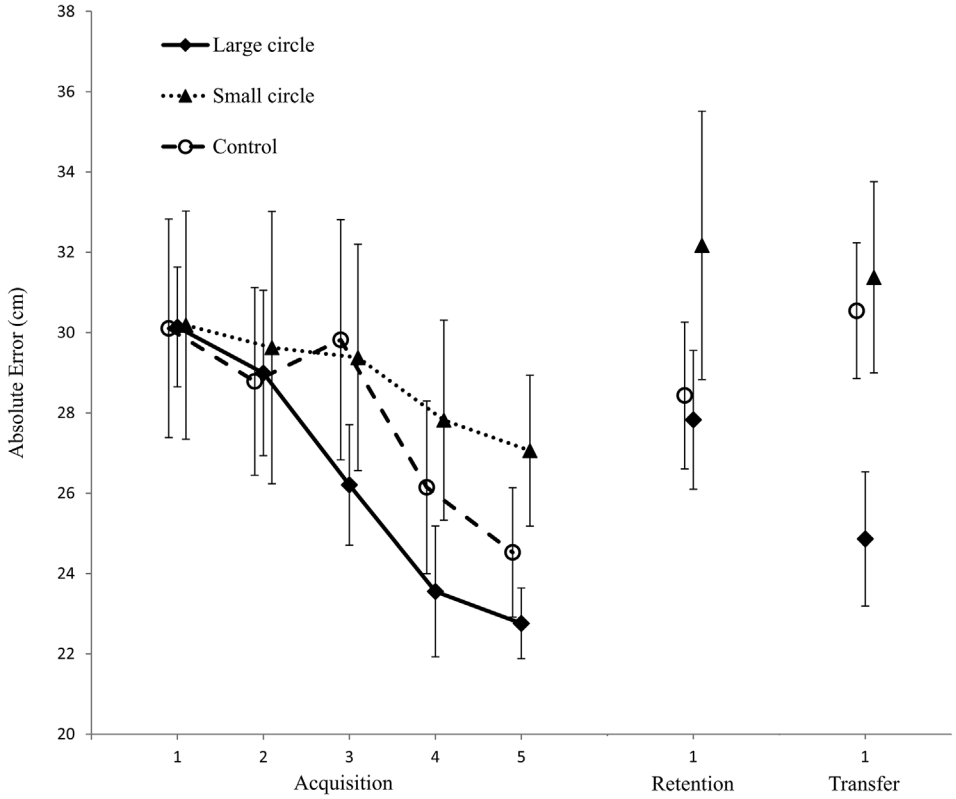

Fig. 1. Means and standard errors of AE across phases – acquisition (five trial blocks), retention (one trial block), and transfer (one trial block).

41) = 0.90, p = .41, η_p^2 = .04. However, for the transfer test, the one-way ANCOVA revealed a significant group difference, $F(2, 41) = 3.37$, p = .04, η_p^2 = .14. Pairwise comparisons using the least significance difference indicated that AE in the LCG (24.88 cm) was lower than in both the SCG (31.28 cm, p = .02) and the CG (30.63 cm, p = .04).

3.3. Number of balls landing inside the circles

The analysis revealed that a greater number of balls landed in the large circle (7.4, 14.8%) than in the small circle (2.5, 5%), $t(28) = 5.07$, $p < .001$, Cohen's $d = 1.85$.

4. Discussion

We attempted in the current study to examine whether performance expectancies enhance or diminish skill learning. In a study on a putting task in golf (Palmer et al., 2016) in which two circles of different sizes surrounded a target, the putting practice aimed at the large circle (14 cm in diameter) led to enhanced performance expectancies, which resulted in better retention and transfer performance, compared to the putting practice aimed at the small circle (7 cm in diameter). However, since a control group was not included in Palmer et al.'s study, it is difficult to determine whether the large circle led to improved performance or the small circle led to diminished performance.

One possible reason why Palmer et al. (2016) did not include a control group in their study might be that success can be perceived as relative. It was found in Palmer et al.'s study that greater expectancy of success (the LCG) during practice led to more effective learning than did lesser expectancy of success (the SCG). However, how each of these conditions would compare to a control condition may be relative. For example, if circles with diameters of 14 cm and 16 cm had been used, both might have shown enhanced learning relative to a control group. With the use of very small circles, the opposite might have been the case – that is to say, different patterns of results are possible.

However, in another study that examined enhanced expectancies in the learning of an anticipation timing task (Chiviacowsky et al., 2012), the performances of participants in a control group and of participants who were told that a relatively large error was considered a success were better than those of participants who were told that only a small error was considered a success. Therefore, it can be concluded that in Chiviacowsky et al.'s (2012) study, performance was diminished by presenting a difficult criterion for success rather than enhanced by presenting an easy criterion for success.

Our aim in the current study was not only to replicate Palmer et al.'s (2016) study on golf putting, but also to add a control group in order to be able to assess whether a large circle around the target enhanced putting performance or whether a small circle diminished it, in line with Chiviacowsky et al.'s (2012) procedure. Our assumption was that the participants practicing with the presence of a large circle around the target will perform better than those practicing with the presence of a small circle or those practicing without a circle. The findings that emerged from our study partially support our assumption as well as the findings of Palmer et al. (2016). AE in the transfer task was significantly smaller in the LCG than in the SCG and CG. The effect sizes of the differences in the transfer task in Palmer et al. (2016) and in our study were virtually the same (η_p^2 = .13 and .14, respectively). However, while in Palmer et al.'s study the performance of the participants in the LCG was better than the performance of those in the SCG throughout all phases of learning – the five practice blocks (η_p^2 = .13), retention test (η_p^2 = .14), and transfer test, in the current study differences were observed only in the transfer test (η_p^2 = .02 and .04 for group differences during acquisition and transfer, respectively).

The differences between the findings of the Palmer et al. (2016) study and our study can be explained, at least in part, by the methodology used in the two studies. In the Palmer et al. study, the two circles – large and small – were presented to all the participants. Therefore, the participants who were told that landing the ball inside the large circle was considered a good performance may have had higher self-efficacy

and higher expectations of success right from the start. It could then be suggested that showing both circles and allowing participants to perceive relative size differences led to improved performance right from the beginning of the acquisition stage. Indeed, one of the predictions of the OPTIMAL theory is that a sense of challenge with expectations of success will contribute to learning (Wulf & Lewthwaite, 2016).

In contrast, in our study only one circle surrounded the target for each group. That is, only the absolute size of the circle was available, and therefore no comparison between the circles was possible. It was only after one or two blocks of practice that the participants in the LCG began to experience enhanced expectancies, since they probably found that they often succeeded. Indeed, as can be seen in Figure 1, a trend similar to the findings of Palmer et al. (2016) can be observed. Differences in performance began to appear at the third block of acquisition. It is also possible, then, that the differences between the groups would have reached statistical significance if several more practice blocks had been included.

Regardless of the reasons for the differences between the two studies, the results of the current study provide further support for the assumption that it is indeed enhanced expectancies that improve performance, because the only difference between the LCG and SCG was in the number of balls that landed inside the circle (14.8% and 5% for the LCG and SCG, respectively). This difference was solely due to the size of the circle, since the mean AE was similar between the two groups (26.3 cm and 28.8 cm for the LCG and SCG, respectively). In essence, the only difference between these two groups was in their perception of success.

Similar findings were revealed in a study where four groups of participants were asked to perform a manual video-aiming task that required learning a new model of limb kinematics (Trempe et al., 2012). The participants were given either an easy objective or a difficult objective, and performed either a 5-min or a 24-h retention test. Performance during practice was similar between groups. However, the participants who were given an easy objective subjectively rated their performance significantly better than those who received the difficult one. Following a 24-h retention interval, the participants who felt successful also performed better than those who did not feel successful and those who performed the retention test after 5 min. In contrast to these findings, in Palmer et al.'s (2016) study, the participants in the LSG performed significantly better than those in the SCG throughout all phases of the study. Thus, it is possible that the differences in both the retention test and transfer test in Palmer et al.'s study were due to the actual level of performance rather than the expectations of success.

Two complementary explanations can be put forward to explain how enhanced expectancies of success can improve performance: the effects of feedback and the effects of psychological suggestion on performance. The effects of different types and schedules of feedback on motor performance have been studied extensively (for reviews, see Kluger & DeNisi, 1996; Sigrist, Rauter, Riener, & Wolf, 2013; Wulf & Shea, 2004). Studies have also shown that providing feedback after successful trials as opposed to after unsuccessful trials can lead to improved performance (e.g., Badami et al., 2012; Chiviacowsky & Wulf, 2007). For example, in one study on golf putting (Badami et al., 2012), one group of participants received feedback after the most accurate trials and another group received feedback after the least accurate trials, while performing 60 putts. The participants who received feedback after accurate trials showed higher self-confidence and performed better in a retention test. In the current study, participants in both the LCG and SCG were told that a trial in which the ball landed inside the circle was considered successful. Since landing the ball inside the large circle was easier, participants in the LCG received three times as many feedbacks of success compared to the SCG. Another type of feedback – bandwidth feedback – has been shown to affect the learning and performance of a motor task. This type of feedback provides knowledge of results (KR) for "correct" or "good" performance within certain boundaries, and provides information about errors outside those boundaries (see Schmidt et al., 2018). In general, providing a large bandwidth for correct performance improves consistency (Sherwood, 1988) as well as automaticity (Agethen & Krause, 2016). In our study, the LCG was provided with a larger bandwidth of "good" performance compared to the SCG, and this may have led to the improved transfer performance. However, quantitative error feedback – distance from the target in centimeters – was provided to the participants as augmented feedback regardless of the final location of the ball. Therefore, this was not a "typical" bandwidth feedback in which qualitative KR for correct responses within a certain bandwidth and quantitative KR outside the bandwidth were provided to the participants (Wulf & Shea, 2004). While more positive feedback was provided for the LCG, error feedback was similar among all groups.

There are data to show that bandwidth feedback or feedback after successful trials can lead to better performance compared to feedback after unsuccessful trials, however the underlying reason for this is not readily apparent. One possible explanation is the role of psychological suggestion in human behavior.

Psychological suggestion refers to an influence on one's cognition and behavior (Michael et al., 2012). As mentioned before, one common explanation for this influence lies in the response expectancy theory (Kirsch, 1997). For example, one can expect to feel better after taking pain medication, or to feel more alert after drinking an energy drink. In motor skill acquisition, performance can be either enhanced or diminished after drinking placebo caffeine, depending on whether the participant believes that caffeine improves or hinders performance, respectively (Kirsch & Weixel, 1988). In the current study, it is possible that compared to the participants in the SCG, the participants in the LCG believed more strongly that they were successful. Following the response expectancies theory (Kirsch, 1997) and the more recent OPTIMAL theory (Wulf & Lewthwaite, 2016), this belief may have led to self-fulfilling behaviors such as external focus of attention, better gaze control, and better care while aiming. Such patterns of behavior may have led to the improved performance in the transfer test. In addition, the OPTIMAL theory suggests several other mechanisms that may underlie the improved performance of the LCG. Such mechanisms include increased self-efficacy, positive affect, and effects on cognition and attention that eventually lead the performer to increased focus on the task goal.

One may expect that enhanced expectancies would affect both practice performance and learning. While this was not the case in our study, the trend depicted in Figure 1 shows that, while not statistically significant, the LCG appeared to improve more than both of the other groups in the acquisition blocks. Still, in the current study only learning (i.e., performance in the transfer test) and not performance (i.e., performance during the acquisition blocks) was significantly affected by the size of the circle around the target. Therefore, it is important to consider the possible effects of practice conditions on motor learning consolidation – a neural process that continues after training has ceased (Brashers-Krug, Shadmehr, & Bizzi, 1996), and by which short-term memory and fragile memory develop into a more stable, long-term form (Shadmehr & Brashers-Krug, 1997).

Indeed, consolidation can be affected by explicit and implicit systems at the time of practice. In general, learning moves from the explicit system to the implicit system, and the implicit learning may be hindered when the explicit system is reengaged (Song, 2009). It can be speculated from our study that their enhanced expectancies led the participants in the LCG earlier to a more implicit state, therefore promoting offline learning consolidation. This argument can be explained by the OPTIMAL theory, which suggests that enhanced expectancies can lead to increased focus on task goals rather than on incompatible task concerns or self-focus. However, a number of other factors that may have affected motor learning consolidation (e.g., hours and timing of sleep cycles, stages of sleep) were not recorded or controlled for.

From a practical perspective, putting is one of the most commonly-used strokes in golf, both in practice and competition settings.

Beginning and advanced golfers alike allocate a considerable amount of time in their practice sessions to improving the accuracy of the putting task, in order to achieve a high level of proficiency (Stirling, 1994; Wesson, 2009). It is true that in putting (a) the golfer is asked to hit a stationary ball compared to other sports where athletes are required to hit a moving object (e.g., baseball, hockey, tennis), (b) the distance between the golfer and the hole is relatively short, and (c) he/she can see the hole clearly and can follow the path of the ball towards the hole. However, the putting task is perceived as a challenging and complex closed self-paced motor task (Wilson & Falkel, 2014). Therefore, an effective manipulation of the learning environment (e.g., the use of various large-sized circles as targets) should assist the beginning golfer in improving his/her putting skills. In essence, the use of a large circle will positively influence the provision of feedback and the golfer's perception of success.

The use of large-sized circles is an example of how coaches and instructors in golf can benefit from the implementation of instructional aides to facilitate performance when working with beginning/novice learners. Indeed, coaches often use instructional aides to assist beginning players in acquiring the foundations of the various strokes in golf (see, for example, Stirling, 1994; Wesson, 2009). If the use of large-sized circles has the potential to positively influence the golfer's perception of success, it is assumed that other golf-relevant instructional aides might play a similar instructional role. Among these aids are a line drawn on the course to assist the golfer in aiming at the hole or a dot drawn on the ball to help the golfer follow the pathway of the rolling ball.

However, the benefits associated with the abovementioned instructional aids are questionable. For example, a narrow line drawn on the course may provide a clear pathway for the golfer to aim at the hole, however it would probably be difficult for him/her to accurately follow this line. In essence, it would be a challenge not to deviate from the drawn line. A deviation from the line may be perceived as negative feedback by the golfer, and therefore has the potential to hinder performance. Consequently, it might be more effective for the coach to draw two parallel lines with a distance of 15–20 cm between them, enabling the golfer to use a large pathway while aiming the ball at the target. A wide pathway may engender more confidence in the golfer in his/her putting attempts, since it is relatively easy to hit the ball within these two lines. From an instructional aids perspective, the use of a drawn narrow line on the course may correspond to the use of small circles surrounding the hole, while the use of two parallel lines may correspond to the use of large circles surrounding the hole. Additional studies are needed to justify the contribution of such instructional aids to the common goal – high achievement in golf.

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