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Different task success criteria affect expectancies of success but do not improve golf putting performance

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ABSTRACT

This study examined how providing different criteria for success affected perceived expectations of success, performance, and learning in a golf-putting task. Twenty-nine physical education students were divided into three experimental groups: (a) a large-circle (LC) group that practiced 10 blocks of five putts, each with a 40 cm diameter circle around the target; (b) a small circle (SC) group that practiced with a 10 cm diameter circle around the target; and (c) a control (C) group that practiced with a 25 cm diameter circle around the target. Forty-eight hours after practice, the participants performed a retention test and a transfer test with a 25 cm diameter circle. The transfer test included putting from a greater distance and from a different angle. Throughout the study, we asked the participants to tell us what they think their chances are to land 1, 2, 3, 4, and 5 balls out of 5 possible balls in each block. There were four main findings: (a) the SC group had lower expectancies of success compared with the LC and C groups in acquisition; (b) there were no group differences in performance or learning among groups; (c) golf club kinematic parameters worsened in the transfer test; and (d) the LC group reduced their expectancies of success from the retention to the transfer test, but the expectancies of the SC and C groups remained the same. We conclude that changes in success criteria affect expectancies of success but do not affect actual putting performance or learning.

One's expectancies of success can be increased by various instructional techniques, among them presenting visual illusions (Chauvel, Wulf, & Maquestiaux, 2015; Witt, Linkenauger, & Proffitt, 2012), providing feedback after "good" rather than "bad" trials (Badami, Vaez-Mousavi, Wulf, & Namazizadeh, 2012; Chiviacowsky & Wulf, 2007), and providing easy criteria for good performance (Trempe, Sabourin, & Proteau, 2012). Indeed, enhanced expectancies of success is one of the cornerstones of a more recent theory of motor learning – the OPTIMAL theory (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 proposed four mechanisms of the theory suggest that expectations for good performance may assist the learner in experiencing successful movement through diverse effects – at the cognitive, motivational, neurophysiological, and neuromuscular levels.

Two interventions that can enhance expectancies of success are providing visual illusions and making changes in the task success criteria. Indeed, both visual illusions and changing success criteria can modulate perceived task difficulty. Four studies using the Ebbinghaus illusion showed that projecting small circles around a circular target led to increased perceived target size and improved golf-putting performance and learning (e.g., Bahmani, Wulf, Ghadiri, Karimi, & Lewthwaite, 2017; Chauvel et al., 2015; Witt et al., 2012, Wood, Vine, & Wilson, 2013). Another study of skilled shooters found increased perceived target size and improved shooting performance (but not learning) when small circles were placed around the target (Bahmani, Diekfuss, Rostami, Ataee, & Ghadiri, 2018). In contrast to the above-mentioned studies, Maquestiaux et al. (2020, Exp. 2 and Exp. 3) found that the Ebbinghaus illusion affected target size perception when both illusions were shown side by side but did not affect putting performance. Moreover, Cañal-Bruland, van der Meer, and Moerman (2016) found that participants who perceived the target as larger did not improve their marble shooting performance, while participants who perceived the target as smaller (and participants in a control group who trained

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without the illusion) did enhance their performance. importantly, while the illusion led to expected differences in target size, it did not lead to differences in the participants' confidence in their performance. The contradictory findings of the abovementioned studies suggest that more research is needed to better understand the effects of the Ebbinghaus illusion on performance.

The results of the studies that changed the definitions of success criteria for enhancing expectancies of success are also contradictory. Three studies on golf putting reported that providing participants with easy criteria for success leads to improved task performance (Palmer, Chiviacowsky, & Wulf, 2016; Ziv, Lidor, et al., 2019; Ziv, Ochayon, et al., 2019). The authors of these studies placed a small or large circle around a target or a golf hole on an artificial putting surface, and told the participants that if they land the ball inside the circle their performance would be considered successful. Since the circles were of different sizes, participants who practiced with a large circle (easy criterion) managed to land more balls inside the circle compared to participants who practiced with a small circle (difficult criterion). This was accompanied by better performance throughout the acquisition, retention, and transfer stages (Palmer et al., 2016), or in the transfer test only (Ziv, Lidor, et al., 2019; Ziv, Ochayon, et al., 2019). However, these studies did not measure perceived expectations of success.

In contrast to the abovementioned studies, three studies measured perceived expectations of success (dart throwing: Ong, Hawke, & Hodges, 2019 and Ong, Lohse, & Hodges, 2015; balancing: Ong & Hodges, 2018). In general, these studies found that while the participants' expectancies of success differed according to changes in definitions of success criteria, their performance was similar. For example, Ong et al. (2019) manipulated the target size in a dart-throwing task. The participants who threw darts to a large target had greater expectations of success compared to participants who threw darts to a small target. However, the participants in the large-target group did not perform better than the participants in the small-target group in the acquisition, nor did they learn the task better as measured in the retention and transfer tests.

In summary, when discussing enhanced expectancies due to differences in definitions of success criteria, the three studies on golf putting (Palmer et al., 2016; Ziv, Lidor, et al., 2019; Ziv, Ochayon, et al., 2019) showed that performance was enhanced when the success criteria were easier. However, these studies did not include direct measures of expectancies. In contrast, the studies that did provide measures of expectancies failed to support the claim that enhanced expectancies lead to improved performance and learning (Ong et al., 2015, 2019; Ong & Hodges, 2018). Therefore, it is still unclear whether changing the criteria to influence task success is related to improved performance and learning.

In the current study, we examined the effects of enhanced expectancies by changing success criteria in a golf-putting task, with three purposes in mind: (a) to examine whether differences in success criteria lead to differences in perceived expectations of success in golf putting, (b) to further examine whether changing the criteria after a period of task acquisition alters the perceived expectations of success in a retention test and a transfer test, and (c) to examine whether putting performance and golf club kinematics are affected by these changes in perceived expected success.

Four hypotheses were proposed in the current study. First, easier success criteria will lead to enhanced perceived expectations of success during acquisition. Second, easing the criteria will increase expectancies of success, and making the criteria more difficult will lower expectancies of success. Third, task performance and learning will improve with increased expectations of success and will decline when expectations of success are low. Finally, as far as we know, previous studies on enhanced expectancies in golf putting did not measure golf club kinematics. Club kinematics differentiate between expert and novice golfers, and are related to putting accuracy and performance (e.g., Gray, Allsop, & Williams, 2013; Sim & Kim, 2010). Therefore, our fourth hypothesis is that, like putting performance, club kinematics will be more optimized with increased expectations of success and less optimized when expectations of success are low.

1. Method

1.1. Participants

Due to the COVID-19 pandemic, our laboratory was closed before we were able to recruit the number of required participants based on an a priori power analysis. Still, 29 physical education students participated in the study (22 females; mean age = 22.8 ± 2.4 years). Because we could not reach the a priori sample size, we conducted a posteriori power analyses.

The participants were randomly assigned into three experimental groups: (a) a large-circle training group (LC, $n = 10$); (b) a small-circle training group (SC, $n = 10$); and (c) a control group (C, $n = 9$). The random assignment to the groups was accomplished using permuted block randomization, which was done using R (R Core Team, 2013). All the participants signed an informed consent form prior to participation in the study. The study was approved by the Ethics Committee of the Academic College at Wingate.

1.2. Tasks

Participants were asked to perform two tasks – an acquisition/retention task and a transfer task (Fig. 1). In the acquisition/retention task, the participants used a putter to putt golf balls (42.7 mm diameter) on an artificial green (2.75 × 0.91 m) from the middle of the putting green and at a distance of 2.00 m, to a 1 cm diameter red dot. For the transfer task, the putting was performed from a distance of 2.33 m and from an angle of 8.6° (Fig. 1). During the acquisition task, a circle with a diameter of 40 cm was placed around the target for the LC group, a circle with a diameter of 10 cm for the SC group, and a circle with a diameter of 25 cm for the C group. For the retention and the transfer tests, a circle with a diameter of 25 cm was placed around the target for all groups. In contrast to previous studies that included a control group that putted to a target with no surrounding circle (Ziv, Lidor, et al., 2019; Ziv, Ochayon, et al., 2019), we placed a circle around the target in the C group as well. We applied this procedure in order to uncover differences that are not related to the presence (or absence) of a circle surrounding the target.

During the putts, a stroke analysis system was used to record each putt (TOMI Pro, TOMI.com, USA). This system measures the club alignment, path, angle, speed, tempo, and duration.

1.3. Procedure

The study took place in the Motor Behavior Laboratory on two occasions, with 48 h in between.

Day 1. On Day 1, the participants took part in the acquisition stage. After signing an informed consent form, the experimenter gave the participants technical instructions on how to putt a golf ball. Then, the experimenter set up and calibrated the stroke analysis system. The participants first performed 10 putts for familiarization and pre-test. In these trials, only a 1 cm diameter red dot was placed as a target on the artificial green. No surrounding circles were placed around the target. Then, 10 blocks of five putts were performed. After each putt, the experimenter measured the X and Y coordinates of the ball in relation to the target. Before the first, fourth, and seventh block of the acquisition putts, the participants were asked how certain they were, on a scale from 0 to 100%, that they would be able to land one of five, two of five, three of five, four of five, and five of five putts in the next block. The participants in all groups were told that the aim was to land each putt as close as possible to the target, and that if the putt landed within the surrounding circle their putt would be considered successful. This protocol

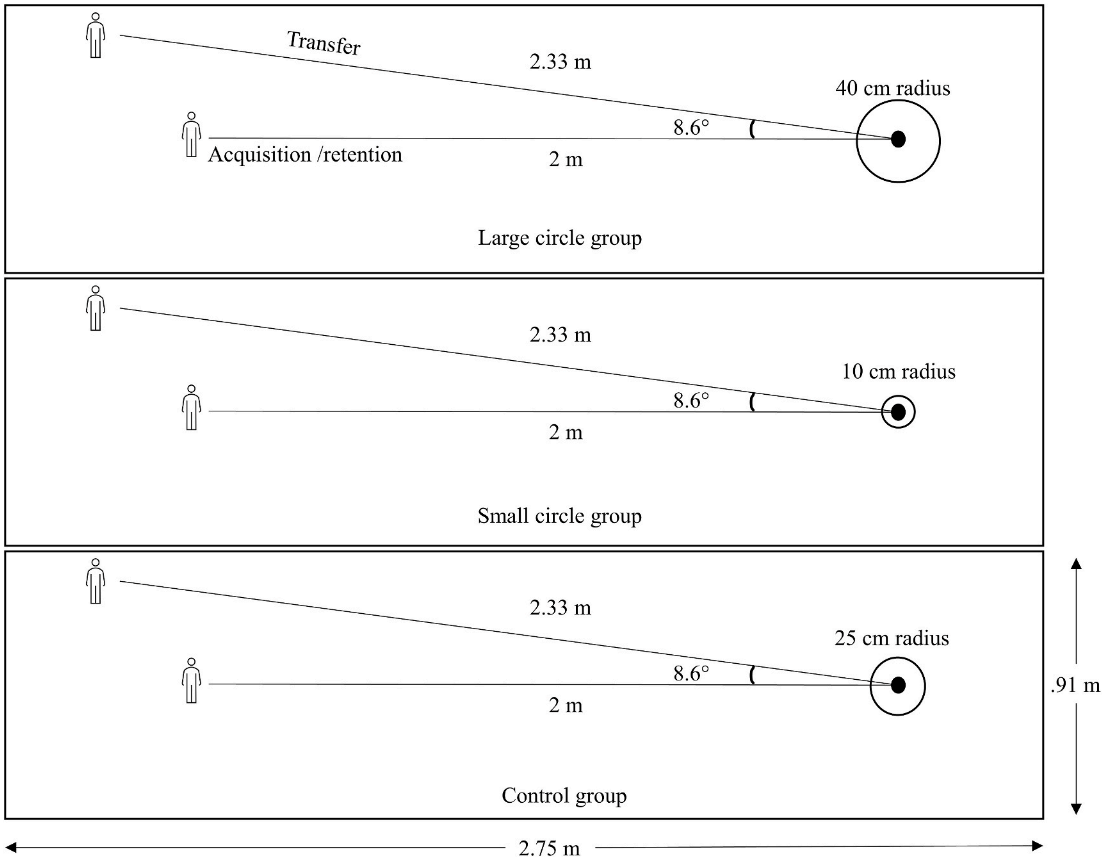

Fig. 1. Illustrations of the tasks for all experimental groups.

was implemented in order to create different success expectancies, as each group putted with a circle of a different diameter, and therefore each group had a different criterion for success (easy/moderate/difficult).

Day 2. On Day 2, the retention and transfer tasks were performed. Prior to the initiation of the retention task, the experimenter showed each participant the change in the circle around the target. For the LC group, the large circle (40 cm diameter) was placed first, then the medium circle (25 cm diameter) was put in place and the 40 cm circle was removed. The participant was told that now the task is more difficult. For the SC group, the small circle (10 cm diameter) was placed first, then the medium circle (25 cm diameter) was put in place and the 10 cm circle was removed. The participant was told that now the task is easier. For the C group, no change was made in the size of the circle (25 cm diameter).

After the change of the circle, we asked the participants about their chances to land one of five, two of five, three of five, four of five, and five of five putts within the circle. Then, the experimenter calibrated the stroke analysis software and the participants performed three blocks of five putts. After the retention task was completed, the transfer task took place. The experimenter repositioned the participants to the new position of the putt and recalibrated the stroke analysis software. We asked the participants again about their chances to land one to five putts within the circle. The participants then performed three blocks of five putts from the new distance and angle. In both the retention and transfer tests, we asked the participants to state their expected success only prior to the first block.

1.4. Dependent variables

We measured three performance variables, five perception variables, and six club kinematic variables. The three performance of success variables were: (a) absolute error (AE) – the distance in cm from the location where the ball landed to the target, in absolute values; (b) variable error (VE) – a measure of putting consistency calculated as: $VE = \left\{ \left(\frac{1}{k}\right) \sum_{i=1}^{k} [(x_i - x_c)^2 + (y_i - y_c)^2] \right\}^{1/2}$ (Hancock, Butler, & Fischman, 1995); and (c) the number of balls that landed within the circle surrounding the target. To calculate AE and VE, we measured the x and y coordinates of the center of the ball relative to the x-axis and y-axis of an imaginary coordinate system with an origin at the center of the target.

The five perception-of-success variables were the chances from 0 to 100% that they could land one, two, three, four, or five balls out of five within the circle surrounding the target. These variables were then averaged to a single perceived success percentage. The club kinematic variables included: (a) the alignment of the club at the time of ball impact – measured in ± degrees (i.e., club face open or closed to the target line); (b) the path of the club at impact – measured in degrees the stroke path cuts across the target line at impact; (c) the shaft angle at impact – measured in tenths of a degree relative to a perfect vertical line; (d) the speed of the club at impact – measured in inches per second; (e) stroke tempo – the relative timing of the backstroke and the forward stroke; and (f) stroke duration – the time in seconds from the beginning of the backstroke to ball impact. We used these kinematic measures because they represent variables that can potentially affect putting accuracy and consistency. More specifically, the speed of the club will determine vertical accuracy and consistency and the club's alignment/path will determine lateral accuracy. Similar variables (e.g., alignment, path, club speed at impact, and stroke duration) were recorded in previous studies (Gray & Cañal-Bruland, 2015; Toner, Moran, & Jackson, 2013; Toner & Moran, 2011).

1.5. Statistical analyses

A one-way analysis of variance (ANOVA) was performed to assess differences between groups at pre-test (familiarization) for the performance variables, club kinematic variables, and for the total number of balls landing within the circles surrounding the target during the acquisition trials (a manipulation check). Two-way ANOVAs were conducted to assess expected success, performance, and golf club kinematics separately for (a) the pre-test, retention test, and transfer test, and (b) the 10 blocks of acquisition. Relevant effect sizes were reported for each analysis. A False Discovery Rate (FDR) (Benjamini & Hochberg, 1995) and Bonferroni post-hoc analyses were performed to control for multiple comparisons, when required. A posteriori statistical power values were reported for all main statistical analyses (main factors and interactions). All statistical analyses were considered significant at $p < .05$.

2. Results

2.1. Pre-test

There were no statistically significant differences between the groups in any of the performance variables or the club kinematic variables ($p > .05$ for all tests).

2.2. Manipulation check

A one-way ANOVA revealed that the total number of balls landing within the circle that surrounded the target during the acquisition stage differed between groups, $F\,(2, 26) = 32.05$, $p < .01$, $\eta^2_p = .71$, power = 1.00. A Bonferroni post-hoc analysis indicated that the number of balls landing within the circle in the LC group (23.10 ± 7.05, 46%) was higher than in the C group (11.78 ± 2.78, 24%, $p < .01$, $\eta^2_p = .53$) and SC group (3.50 ± 5.54, 7%, $p < .01$, $\eta^2_p = .70$). The difference between the SC and the C group was also significant ($p > .01$, $\eta^2_p = .47$).

2.3. Pre-, retention, and transfer tests

2.3.1. Expected success

Expected success was not measured during the pre-test. A two-way ANOVA [Group X Test (retention, transfer)] with repeated measures on the Test factor revealed a Test effect, $F\,(1, 26) = 22.73$, $p < .01$, $\eta^2_p = .47$, power = 1.00. The mean expected success prior to the retention test (36.33 ± 21.09%) was higher than prior to the transfer test (26.47 ± 19.63%) ($p < .01$, $\eta^2_p = .05$). There was a trend towards statistical significance in the Group effect, $F\,(2, 26) = 3.1$, $p = .06$, $\eta^2_p = .19$, power = .55, and in the Group × Test interaction, $F\,(2, 26) = 2.97$, $p = .07$, $\eta^2_p = .19$, power = .53.

Since the two latter analyses showed a trend towards statistical significance, we decided to analyze the 95% confidence intervals (CI). This analysis showed that the mean expected success of the SC group (21.13 ± 10.16%, CI: 9.29–32.97) was lower than that of the C group (41.90 ± 21.39%, CI: 29.42–54.38), but similar to that of the LC group (32.23 ± 21.17, CI: 20.39–44.07) (see Fig. 2a). In addition, the participants in the LC group lowered their expectations of success from the retention test (40.27 + 24.35%, CI: 27.12–53.42) to the transfer test (24.19 ± 19.02%, CI: 12.68–35.70). However, the participants in the SC and the C groups did not [(SC group: retention: 25.60 ± 11.64%, CI: 12.45–38.75, transfer: 16.66 ± 11.65%, CI: 5.15–28.17); (C group: retention: 43.89 ± 22.58%, CI: 30.03–57.75, transfer: 39.92 ± 21.44%, CI: 27.78–52.05)] (see Fig. 2b).

2.3.2. Performance

AE. The two-way ANOVA (Group X Test) with repeated measures on the Test factor revealed a main effect for Test, $F\,(1.5, 39.9) = 27.5$, $p < .01$, $\eta^2_p = .51$, power = 1.00. A Bonferroni post-hoc analysis indicated that AE in the retention test (24.75 ± 4.97 cm) was lower than in both the pre-test (39.94 ± 10.84 cm, $p < .01$, $\eta^2_p = .45$) and the transfer test (38.12 ± 7.84 cm, $p < .01$, $\eta^2_p = .50$). The main effect for Group, $F\,(2, 26) = 0.19$, $p = .83$, $\eta^2_p = .01$, power = .08, and the interaction, $F\,(4, 52) = 1.1$, $p = .37$, $\eta^2_p = .08$, power = .32, were not found to be significant.

VE. The two-way ANOVA (Group X Test) with repeated measures on the Test factor revealed a main effect for Test, $F\,(2, 52) = 11.37$, $p < .01$, $\eta^2_p = .30$, power = .99. A Bonferroni post-hoc analysis showed that VE in the retention test (25.79 ± 5.91 cm) was lower than in both the pre-test (31.51 ± 11.39 cm, $p < .01$, $\eta^2_p = .08$) and the transfer test (35.29 ± 7.68 cm, $p < .01$, $\eta^2_p = .33$). The Group main effect, $F\,(2, 26) = 0.69$, $p = .51$, $\eta^2_p = .05$, power = .15, and the interaction, $F\,(4, 52) = 1.43$, $p = .24$, $\eta^2_p = .10$, power = .41, were not found to be significant.

2.3.3. Golf club kinematics

Statistical significance values for all six club kinematic variables are presented in Table 1. After using FDR to control for multiple comparisons, the analyses revealed that (a) club alignment at impact (2.41 ± 2.39°) was greater in the transfer test compared to the retention test (0.53 ± 1.16°) and the pre-test (0.15 ± 2.09°) ($p < .01$ and $\eta^2_p > .20$); (b) club path at impact was greater in the transfer test (6.24 ± 5.21°) compared to the retention test (1.07 ± 3.97°) and the pre-test (0.86 ± 2.61°) ($p < .001$ and $\eta^2_p > .23$); (c) club speed at impact was higher in the pre-test (0.96 ± 0.15 m/s) compared to the retention test (0.79 ± 0.1 m/s, $p < .01$ and $\eta^2_p = .30$), but not compared to the transfer test (0.88 ± 0.18 m/s); and (d) stroke tempo (the ratio between the duration of the backstroke and the forward stroke) was lower in the retention test (1.46 ± 0.14) compared to the transfer test (1.56 ± 0.20) and the pre-test (1.58 ± 0.18) ($p < .05$, $\eta^2_p > .08$).

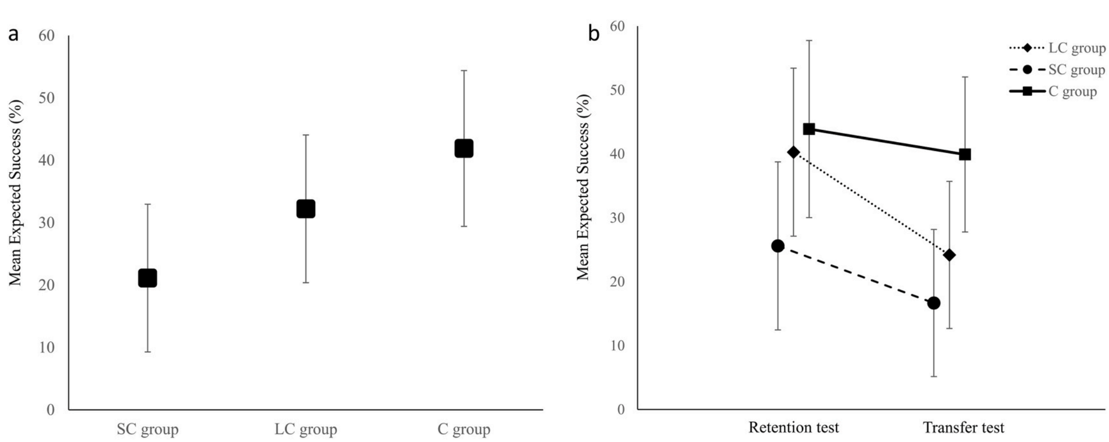

Fig. 2. (a) Differences in expected success between groups averaged over the retention and transfer tests; (b) Differences in expected success between the retention test and the transfer test. Error bars represent 95% confidence intervals.

Table 1
Statistical analyses of the two-way ANOVAs for all six measured kinematic variables. (Significant findings are in BOLD and their post-hoc analyses are presented in the text.).

Phase	Dependent Variable	Effect	F (degrees of freedom)	P value	η^2_p	Power values
Pre-, retention, transfer tests	Alignment of club at impact	Group	.55 (2, 26)	.58	.04	.13
		Test	17.41 (2, 52)	<.001	.40	1.00
		Interaction	.96 (4, 52)	.44	.07	.28
	Path of club at impact	Group	2.92 (2, 26)	.07	.18	.52
		Test	21.99 (2, 52)	<.001	.46	1.00
		Interaction	1.16 (4, 52)	.34	.08	.34
	Shaft angle at impact	Group	.55 (2, 26)	.58	.04	.13
		Test	1.59 (1.5, 38.4)	.22	.06	.28
		Interaction	1.26 (4, 52)	.30	.09	.37
	Speed of club at impact	Group	.73 (2, 26)	.49	.05	.16
		Test	11.75 (2, 52)	<.001	.31	.99
		Interaction	.73 (4, 52)	.58	.05	.22
	Stroke tempo	Group	.16 (2, 26)	.86	.01	.07
		Test	6.16 (2, 52)	.004	.19	.87
		Interaction	.35 (4, 52)	.85	.03	.12
	Stroke duration	Group	1.40 (2, 26)	.27	.10	.27
		Test	4.14 (1.5, 39.11)	.03*	.14	.62
		Interaction	.90 (4, 52)	.47	.07	.27
Acquisition	Alignment of club at impact	Group	1.2 (2, 21)	.33	.10	.23
		Block	2.8 (1.4, 30.3)	.09	.12	.44
		Interaction	.88 (18, 189)	.60	.08	.63
	Path of club at impact	Group	.49 (2, 21)	.62	.05	.12
		Block	2.57 (3.3, 69.2)	.06	.11	.64
		Interaction	.70 (18, 189)	.81	.06	.50
	Shaft angle at impact	Group	.34 (2, 21)	.72	.03	.10
		Block	1.42 (4.1, 86.1)	.23	.06	.43
		Interaction	1.15 (18, 189)	.31	.1	.77
	Speed of club at impact	Group	1.14 (2, 21)	.34	.1	.22
		Block	.20 (3.4, 72.2)	.92	.01	.09
		Interaction	1.89 (18, 189)	.02*	.15	.96
	Stroke tempo	Group	.33 (2, 21)	.73	.03	.10
		Block	1.63 (3.6, 75.0)	.18	.07	.45
		Interaction	1.02 (18, 189)	.44	.09	.71
	Stroke duration	Group	.97 (2, 21)	.39	.09	.20
		Block	.63 (3.3, 69.0)	.61	.03	.18
		Interaction	.72 (18, 189)	.79	.06	.52

*Not significant after correcting for multiple comparisons using FDR.

2.4. Acquisition

2.4.1. Expected success

A two-way ANOVA [Group X Block (Block 1, Block 4, Block 7)] with repeated measures on the Block factor revealed a Group effect, F (2, 26) = 8.59, p = .01, η^2_p = .40, power = .95. A Bonferroni post-hoc analysis found that the mean expected success in the SC group (16.78 ± 17.15%) was lower than both the LC group (50.81 ± 16.95%, p < .01, η^2_p = .50) and the C group (42.55 ± 23.05%, p = .02, η^2_p = .30). There were no significant differences between the LC and C groups. In addition, there was no Block effect, F (1.6, 41.7) = 1.17, p = .32, η^2_p = .04, power = .22, and no Block × Group interaction, F (4,52) = 1.86, p = .13, η^2_p = .13, power = .53.

2.4.2. Performance

AE. The two-way ANOVA (Group X Block) with repeated measures on the Block factor revealed a main effect for Block, F (9, 234) = 4.23, p < .01, η^2_p = .14, power = .99. A Bonferroni post-hoc analysis revealed that the AE in Blocks 6 and 7 (23.70 ± 6.53 cm, 24.17 ± 6.56 cm, respectively) was lower than in Blocks 1 and 2 (31.38 ± 7.89 cm, 31.17 ± 8.78 cm, respectively) (for all comparisons, p < .04, η^2_p > .17). Neither the main effect for Group, F (2, 26) = 1.23, p = .31, η^2_p = .09, power = .24, nor the interaction, F (18, 234) = 1.34, p = .17, η^2_p = .09, power = .86, was found to be significant.

VE. The two-way ANOVA (Group X Block) with repeated measures on the Block factor revealed no Group main effect, F (2, 26) = 0.63, p = .54, η^2_p = .05, power = .14, no Block main effect, F (9, 234) = 1.43, p = .18, η^2_p = .05, power = .68, and no interaction, F (18, 234) = 0.87, p = .62, η^2_p = .06, power = .62.

2.4.3. Golf club kinematics

The two-way ANOVAs for all six of the club kinematic variables did not reveal any significant differences (see Table 1).

3. Discussion

The current study examined whether advising participants that landing a golf ball inside circles of different sizes would lead to differences in expectancies of success, performance, learning, and golf club kinematics. We hypothesized that (a) easier success criteria will lead to enhanced perceived expectations of success during acquisition; (b) easing the criteria will increase expectancies of success, and making the criteria more difficult will lower expectancies of success; (c) task performance and learning will improve with increased expectations of success and decline when expectations of success are low; and (d) golf club kinematics will be more optimized with increased expectations of success and less optimized when expectations of success are low. Our findings only supported the first hypothesis. During acquisition, the SC group had lower expectancies of success compared with the LC and C groups. Two more important findings were: (a) when averaging the retention and transfer tests, the SC group tended to have lower expectancies of success compared with the C group; and (b) the participants in the LC group tended to reduce their expectancies of success from the retention test to the transfer test, while the SC and C groups did not.

3.1. Enhanced expectancies of success, performance, and learning

The finding that enhanced expectancies of success do not lead to improved task performance and learning is in line with the findings of two previous studies on dart throwing (Ong et al., 2015, 2019), and contradicts the predictions made in the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016). However, we used only one (i.e., changing the criteria for success) out of several techniques available (e.g., providing visual illusions, providing feedback after "good" rather than "bad" trials, providing positive social feedback) to change the expectancies of success. It is possible that other techniques could be more effective in positively influencing performance and learning.

Moreover, the findings of the current study contradict three previous studies that showed improved performance and learning when using large rather than small circles around a target (Palmer et al., 2016; Ziv, Lidor et al., 2019; Ziv, Ochayon, et al., 2019). There are other dissimilarities between the current study and the abovementioned three previous studies. First, in the current study the size of the surrounding circle was changed before the retention and transfer tests for the participants in the SC and the LC group, while for the participants in the C group the size remained the same. Second, in order to make sure that the participants understood the meaning of the changes in circle size, we told them that the change in the size of the surrounding circle makes the task less or more difficult. These differences may have contributed to the dissimilar findings between the current study and the three abovementioned studies. However, and regardless of these dissimilarities, differences between groups in expectancies of success in the current study were not accompanied by differences in performance and learning.

One other difference between the current study and these three studies is noteworthy – the current study included a measure of success expectancy, whereas Palmer et al. (2016), Ziv, Lidor et al. (2019), and Ziv, Ochayon, et al. (2019) did not. Other previous studies that measured expectancy failed to find a relationship between different success criteria, performance, and learning (Ong et al., 2015, 2019; Ong & Hodges, 2018). Hence, the three studies that manipulated success criteria but did not measure expectancies of success found a positive effect on performance and/or learning (Palmer et al., 2016: both performance and learning; Ziv, Lidor et al., 2019; Ziv, Ochayon, et al., 2019: learning only). However, four studies (including the current study) that manipulated success criteria and measured expectancies did not find any effect on performance and/or learning.

One possible question that arises is whether asking participants to assess their chances of success throughout the study prevents them from improving their performance and learning. It is possible, for example, that asking participants about their chances of success makes them more aware of their own performance. This, in turn, may lead to internal rather than external focus of attention, a strategy that has been found to negatively affect performance (see Wulf, 2013). If this speculation was true, the expected improved performance due to enhanced expectancies of success could be nullified by the extra effort and conscious control of actions brought about by the internal focus of attention. Future studies can compare various techniques to enhance expectancies of success in participants who are (or are not) made consciously aware of their expectations.

3.2. Changes in perceived expectancies

As hypothesized, the expectancies of success during acquisition were lower in the SC group compared to the LC and C groups. In addition, during the retention and transfer tests, expectations were lower in the SC group compared to the C group [the Group main effect of this analysis approached significance ($p = .06$) with a large effect size ($\eta^2_p = .19$) and post-hoc comparisons using 95% CI revealed this difference]. These findings suggest that changing task success criteria affects expectancies of success, and are in line with previous studies (e.g., Ong et al., 2015; Ong et al., 2019).

The participants in the C group and the LC group had similar expectations. This suggests that above a certain success threshold, confidence in one's performance is not negatively affected. During acquisition, participants in the LC, C, and SC groups landed 46%, 24%, and 7% of the putts within the circle, respectively. It is possible that a success rate of 24% is above the threshold required to maintain higher confidence in one's abilities. Indeed, in two previous studies (Palmer et al., 2016; Ziv, Ochayon, et al., 2019), a large circle around a target led to a success rate of 15–22% and a small circle around the target led to a success rate of 5–8%. The former success rates led to improved putting performance and learning (Palmer et al., 2016) or just learning (Ziv, Ochayon, et al., 2019). It is possible that success rates of between 15 and 24% are sufficient to induce improved motor performance and learning. This is a topic for future research.

We expected that the participants would reduce their expectations of success when facing the more difficult transfer task, but this occurred only in the LC group [the interaction effect of this analysis approached significance ($p = .07$) with a large effect size ($\eta^2_p = .19$) and post-hoc comparisons using 95% CI revealed this difference]. The participants in the C group putted with the same surrounding circle throughout the experiment. They may have gained enough confidence in their performance, and thus the change in task difficulty was not great enough to alter their expectations. The participants in the SC group had low expectations of success throughout the experiment – less than 25% on average – and these expectations remained low, possibly representing a floor effect.

Summing up the results on expected success and performance, our findings suggest that difficult (easy) success criteria lead to low (high) expectations of success, but these differences do not lead to changes in putting performance. These conclusions add to the literature by showing that, similar to previous studies (e.g., Ong et al., 2015; Ong et al., 2019), when participants are asked about their expectancies *during* a study, their performance does not change. This is in contrast to previous studies that did not measure expectancies and found changes in performance based on changes to the definitions of success criteria (e.g., Palmer et al., 2016; Ziv, Lidor, et al., 2019).

We suggest that future studies should compare groups that are being asked and groups that are not being asked about their chances of success during the study. For example, such an experiment can be composed of four conditions: (a) a large circle; (b) a small circle; (c) a large circle in which the participants are asked questions about their expectation of success; and (d) a small circle in which the participants are asked questions about their expectation of success. A similar methodology was used in studies examining the use of feedback after "good" and "bad" trials, in order to assess whether making participants aware of the fact that they actually receive the feedback after their "good" or "bad" trials affected performance differently than participants who received the same feedback but were not made aware of it (Carter, Smith, & Ste-Marie, 2016; Patterson & Azizieh, 2012). In one of those studies (Carter et al., 2016), judgment of learning was higher after good trials – irrespective of awareness, but performance was the same. In another study (Patterson & Azizieh, 2012), awareness of receiving feedback after "good" or "bad" trials led participants to perform better than participants who were not aware of it.

3.3. Golf club kinematics

Club alignment and path worsened in the transfer test compared to the pre-test and the retention test. In the transfer test, the participants putted from 2.33 m (instead of 2 m) and from an angle of 8.6°. The longer distance did not affect club speed. However, the 8.6° change led to a greater misalignment between the club direction and the virtual line that connects the ball and the target.

This finding is surprising, since there is always a straight line between the golf ball and the hole, and in the absence of a slope it should not matter whether a participant is standing at 8.6° from a previous location or from any other extrinsic angular location. However, the changes in the extrinsic angular location led to poorer golf club kinematics. These data suggest that transfer of learning is affected not only by internal representations of the task, but also by external cues. The data also explain, at least in part, the reduced accuracy and consistency in the transfer test compared with the retention test.

The results of the current study have both theoretical and practical implications. From a theoretical standpoint, the results provide information that contradicts the OPTIMAL theory of motor learning, and suggest that more research is required to better understand how enhanced expectancies affect performance. Indeed, the relationship between enhanced expectancies of success and performance may be moderated by the nature of the task and its complexity (see Guadagnoli & Lee, 2004; Wulf & Shea, 2002), by the characteristics of the learner (e.g., the level of expertise, experience), or by an interplay between such variables (Carter et al., 2016). Such possible intricacies should be examined in future research.

From a practical standpoint, our findings support the idea that those who teach motor skills should avoid over-challenging their learners, as such practices may lead (in addition to reduced performance and learning) to low expectancies of success, which may not increase even when task difficulty is reduced. This in turn can potentially lead to reduced self-efficacy (see, e.g., Campbell & Hackett, 1986).

3.4. Success criteria vs. visual illusions – similar interventions, different outcomes?

The effects of easing success criteria and presenting visual illusions – when self-efficacy or confidence are measured as well – lead to different outcomes. Four studies used the Ebbinghaus illusion and measured self-efficacy, performance, and learning. One study found that small circles around a circular target led to increased self-efficacy and improved performance (Bahmani et al., 2018) and two studies reported increased self-efficacy and improved performance and learning (Bahmani et al., 2017; Chauvel et al., 2015). In contrast, only one study found no differences in self-confidence, but reported improved performance when the target was perceived as small due to the projection of larger circles around it (Cañal-Bruland et al., 2016). The literature on success criteria portrays different findings. Four studies showed that easing success criteria enhanced self-efficacy, but did not improve motor performance and learning (Ong et al., 2019; Ong & Hodges, 2018; Ong et al., 2015; and the current study).

The number of studies on these topics is limited, and future studies should be carried out that directly compare the effects of visual illusions and changing success criteria on self-efficacy, performance, and learning. It is possible, for example, that visual illusions are more implicit compared with changing definitions of success criteria, and that the differences between the interventions lie there.

The current study has two limitations. First, the participants in the LC and SC groups could have perceived the change of the circle size from the acquisition phase to the retention test as a different task (i.e., a transfer task). In contrast, the participants in the C group perceived it as the same task (i.e., a retention task) because the circle surrounding the target remained the same throughout the experiment. This detail could have confounded the findings of our study. However, we instructed all participants that their goal was to land the ball as close as possible to the 1 cm diameter target that was within the surrounding circles for all groups. Therefore, we believe that this methodological choice did not bias our results.

Second, the participants in the C group did not face a completely neutral condition, because a 25 cm diameter circle surrounded the target during their practice. This moderately-sized surrounding circle might have affected their perception of success as well. Therefore, it could be argued that the differences found in the current study are between large-, moderate-, and small-sized surrounding circles rather than small-circle, large-circle, and a control group. We suggest that future studies include a neutral control group in addition to the three experimental groups like those in the current study. This could allow researchers to assess whether there is a circle-size threshold in the effect on perceived success and performance.

4. Conclusions

Our findings suggest that changing the definitions of success criteria affects expectancies of success but does not affect golf-putting performance, learning, or golf club kinematics. Specifically, the SC group had lower expectancies of success compared with the LC and C groups in acquisition. In addition, the LC group reduced their expectancies of success from the retention to the transfer test, but the expectancies of the SC and the C groups remained the same.

Author Statement

Gal Ziv: Conceptualization, Methodology, Formal analysis, Writing – Original draft. **Ronnie Lidor:** Conceptualization, Writing – Reviewing and Editing

Declaration of competing interestCOI

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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