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Golf skill learning: An external focus of attention enhances performance and motivation

Jongseong An[a,*], Gabriele Wulf[b]

[a] Busan University of Foreign Studies, South Korea
[b] University of Nevada, Las Vegas, USA

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ABSTRACT

An external focus of attention has been shown to enhance the performance and learning of motor skills, relative to an internal focus (see Chua, Jimenez-Diaz, Lewthwaite, Kim, & Wulf, 2021). In the present study, we examined possible motivational consequences of learners' experience of greater movement success with an external focus. Participants were asked to learn a golf pitch shot. In addition to measuring learning, we assessed self-efficacy, as well as positive and negative affect in groups that received external versus internal focus instructions. Furthermore, we examined the feasibility of providing several focus instructions in the same practice session as the learning of complex skills typically requires more than one instructional cue. The results showed that skill learning was enhanced by instructions that promoted external foci, as measured by golf shot accuracy on delayed retention and transfer tests. The external focus group also showed higher positive affect and reduced negative affect at the end of practice, and higher self-efficacy before retention testing, compared with the internal focus group. These findings provide support for several assumptions of the OPTIMAL theory (Wulf & Lewthwaite, 2016). From a practical perspective, they highlight the attentional and motivational benefits of an external focus.

1. Introduction

Wulf, Höß, and Prinz (1998) first demonstrated the advantages of adopting an external focus (EF) relative to an internal focus (IF) of attention when learning motor skills. An external focus involves a concentration on the intended effect of the movement, such as the motion of an implement (e.g., tennis racquet, trajectory of a frisbee, spin of a ball), hitting a target (e.g., bullseye), or an image (e.g., creating a "platform" with the arms when passing a volleyball, pendulum-type motion of a golf club, "climbing up a cork screw" when performing a pirouette). In contrast, an internal focus refers to a concentration on body movements, such as how to move one's arms, wrists, or hips. In the study by Wulf et al. (1998), the learning of balance tasks was facilitated when learners were given external relative to internal focus instructions. In their Experiment 1, instructions to focus attention on the wheels of a ski simulator (EF) (under the feet) led to more effective learning than did instructions to focus on the feet (IF) themselves. In Experiment 2, instructions to concentrate on keeping markers (EF) (in front of the feet) horizontal resulted in enhanced balance learning compared with instructions to keep the feet (IF) horizontal. Numerous follow-up studies have corroborated those findings. Research on attentional focus has been reviewed in various comprehensive (e.g., Lohse, Wulf, & Lewthwaite, 2012; Wulf, 2007a, 2007b, 2013; Wulf & Lewthwaite, 2010; Wulf & Prinz, 2001) or more focused reviews (e.g., Kim, Jimenez-Diaz, & Chen, 2017; Marchant, 2011; Park, Yi, Shin, & Ryu, 2015; Ziv & Lidor, 2015). Importantly, comprehensive meta-analyses confirmed the superiority of an external focus relative to an internal focus for both immediate performance and learning (Chua, Diaz, Lewthwaite, Kim, & Wulf, 2021). The meta-analyses also showed that the external focus benefits were independent of age, health condition, or level of expertise.

In the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016), an external focus is one of three key factors that are important for effective motor skill learning and performance. The other two key factors are motivational in nature, namely, enhanced expectancies for performance and autonomy support. All three factors are assumed to contribute to *goal-action coupling*, or the fluidity with which the intended movement goal is translated into action (Wulf & Lewthwaite, 2016). In line with this view, it has been demonstrated that an external focus not only improves movement accuracy compared with an internal focus (see Wulf, 2013), but it also enhances movement fluency (e.g., Kal, van der

* Corresponding author. Division of Sports and Leisure Studies, Busan University of Foreign Studies, Busan, 46234 65, Geumsaem-ro 485-gil, Geumjeong-gu, South Korea.

E-mail address: dragonjosh@bufs.ac.kr (J. An).

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Kamp, & Houdijk, 2013; Lohse, 2012), results in greater neuromuscular efficiency (e.g., Greig & Merchant, 2014; Zachry, Wulf, Mercer, & Bezodis, 2005), facilitates economical neural strategies (e.g., Kuhn, Keller, Egger, & Taube, 2021; Kuhn, Keller, Lauber, & Taube, 2018), produces movement kinematics that are typical of skilled performers (e.g., Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015; An, Wulf, & Kim, 2013; Parr & Button, 2009; Singh, Shih, Kal, Bennett, & Wulf, 2022), and results in greater automaticity in movement control (Wulf, McNevin, & Shea, 2001).

An interesting aspect of the greater performance success and faster rate of learning performers experience with an external relative to an internal focus is that it might have positive motivational consequences. In fact, one prediction of OPTIMAL theory is that, "Movement success resulting from an external focus enhances expectancies for future success" (Wulf & Lewthwaite, 2016, p. 1404; Prediction 6). Thus, increased confidence resulting from successful performance with an external focus could potentially contribute to a virtuous cycle of good performance, further increases in self-efficacy, and positive affect – "with overall positive consequences for learning and motivation" (Wulf & Lewthwaite, 2016, p. 1406). Beliefs about their future experiences or performance, including self-efficacy expectations, have been central to theories of human motivation (e.g., Bandura, 1977). Furthermore, interest in the relationship between expectancies and performance has been prominent in social and sport psychology (e.g., Feltz, Chow, & Hepler, 2008; Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008; Wulf, Chiviacowsky, & Lewthwaite, 2012). In the OPTIMAL theory, expectancies signal the degree of anticipated "reward" associated with impending movement experience. Reward in turn triggers the release of dopamine that is important for neuroplastic changes and memory consolidation (Jenkins & Walton, 2020; Manohar et al., 2015; Wise, 2004). Heightened expectancies resulting from good performance with an external focus therefore have the potential to provide additional benefits to performance and learning.

In the present study, we therefore wanted to examine the impacts of the different attentional focus instructions on motivation and learning. We chose a golf pitch shot to examine those effects. We hypothesized that the greater movement success experienced by participants who received external relative to internal focus instructions during practice might be reflected in higher self-efficacy ratings. Self-efficacy was assessed after the practice phase and on the following day (i.e., before the retention test). The rewarding nature of successful performance may also be accompanied by positive affect. Therefore, we also included measures of positive affect as well as negative affect (Watson & Clark, 1994). We expected the external focus group to show greater positive affect and less negative affect than the internal focus group after the practice phase.

Another issue we wanted to examine in the present study was the feasibility of providing several external versus internal focus instructions in the same practice session. Most studies on attentional focus have examined the effectiveness of a single external focus cue with a comparable internal focus cue (see Chua et al., 2021). Yet, many complex real-life skills require the learning of a fundamental movement pattern, or technique, as well as the appropriate scaling or parameterization of the movement, such as force control (Schmidt, 1975). The acquisition of a tennis stroke, basketball jump shot, or pass in football, for instance, necessitates that attention be directed at the proper movement form and the intended performance outcome (i.e., length and direction of the shot or pass). Thus, when teaching such skills, a single instruction will rarely suffice. Golf skills are among those that are notoriously difficult to acquire. In previous golf-related studies, external versus internal focus instructions referred to the motion of the golf club versus arms (Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007), clubhead or ball trajectory versus wrists (Bell & Hardy, 2009), clubhead versus elbow motion (Christina & Alpenfels, 2014), or pressure exerted against the ground versus weight shift to the front foot (An et al., 2013), respectively.

In golf, there are numerous potential foci of attention that are related to movement form, such as swing range, swing tempo, swing plane, swing weight, club face angle, or weight shift. Other foci are more outcome-oriented, such as the intended flight path or landing point of the ball, ball spin, or force control. We chose a combination of technique and outcome-related attentional foci for a task that involved pitching a golf ball to a target. The focus instructions were related to the swing distance, swing weight (i.e., how heavy the club feels when the player swings it), and performance outcome, but they differed slightly for two groups. They were designed to promote an external focus for one group and an internal focus for another group. Also, rather than being provided simultaneously, the instructions were given successively (in a counterbalanced order) during the practice phase. Specifically, one instruction (e.g., related to swing distance) was given at the beginning of practice, while another instruction (e.g., performance outcome) was provided before the second third, and the last instruction (e.g., swing weight) was given before the last third of the practice phase. We hypothesized that the external focus instructions, regardless of order, would result in more effective learning than internal focus instructions as measured by delayed retention and transfer tests. Manipulation checks were included after each practice block to determine the extent to which participants adopted the instructed attentional foci.

2. Methods

2.1. Participants

Thirty-six undergraduate students (28 males, 8 females) participated in this study. All participants had completed a one-semester golf class. G*Power 3.0 was used to determine the minimum sample size. A minimum sample size of 24 participants was calculated with an estimated η_p^2 value of .07 (Wulf, Lewthwaite, Cardozo, & Chiviacowsky, 2018), a power value of 0.90, and α value of 0.05 (Chua, Wulf, & Lewthwaite, 2018). All participants signed an informed consent form. They were naïve as to the specific purpose of the experiment. The study was approved by the university's institutional review board.

2.2. Apparatus and task

Participants' task was to perform a golf pitch shot, with the goal of hitting a bullseye that had a 60-cm diameter and was located at a 10-m distance from the participant (13-m distance on the transfer test). Plastic golf balls and a 46-degree pitching wedge were used. Plastic balls were chosen to accommodate participants' skill level and an indoor setting. In a pilot study, it was determined that the task required a half-swing that would result in a 25-30 m carry distance with regular golf balls. Balls were hit from an artificial turf mat (50 $\times$ 100 cm). There were five concentric circles surrounding the bullseye, creating zones that were 60 cm in width. Five points were given for balls landing in the inner circle (0-60 cm). For balls that landed in the larger zones, four points (60-120 cm), three points (120-180 cm), two points (180-240 cm), and one point (240-300 cm) were awarded. If a ball hit the border between zones, the higher score was recorded. For trials on which the ball landed outside of the largest circle, zero points were given.

2.3. Procedure

Participants were quasi-randomly assigned to one of two groups in the order of appearance and stratified by gender, an external focus (EF) and an internal focus (IF) group. Each participant first watched a demonstration of the pitch shot by a professional golfer and was provided with basic swing instructions (e.g., grip, stance, ball position, body alignment, swing plane). After the initial instructions, participants were asked to perform a pretest consisting of 20 trials without attentional focus instructions from a 10-m distance to the target. Subsequently, they performed three blocks of 20 practice trials, or a total of 60 trials, for the same distance. On each of the three blocks, a different attentional focus instruction was given. Depending on group assignment, the instructions were designed to promote either an external or internal focus. One set of instructions was related to the swing distance (SD), another one to swing weight (SW), and the third one referred to the performance outcome (PO). The order of instructions was counterbalanced among participants, using all six possible orders (SD-SW-PO, SD-PO-SW, SW-SD-PO, SW-PO-SD, PO-SD-SW, PO-SW-SD). On the SD block, participants were instructed to concentrate on a 1:1 swing ratio for backswing and follow-through (EF: "Focus on the 1:1 swing ratio of the club shaft"; IF: "Focus on the 1:1 swing ratio of your arms"). On the SW block, participants were asked to focus on the swing weight (EF: "Focus on the weight of the club head"; IF: "Focus on the grip pressure of your hands"). Finally, on the PO block they were asked to focus on the outcome of their shot (EF: "Focus on the landing point of the ball"; IF: "Focus on your force control"). The instructions were given at the beginning of the respective block and reminders were given before each trial. Between blocks, participants took 2-min breaks. During those breaks, manipulation checks (see below) were conducted. One day after the practice phase, all participants performed a retention test (10-m distance) and a transfer test (13-m distance), each consisting of 20 trials without attentional focus instructions or reminders.

Manipulation checks, self-efficacy ratings, as well as positive and negative affect assessments were included at different time points during the experiment. Manipulation checks were conducted at the end of each of three practice blocks to determine the extent to which participants used the instructed attentional focus on a given block. Participants were asked to indicate their level of adherence to the instruction in percent (0–100%). Self-efficacy was assessed before and after the practice phase, as well as before the retention test and before the transfer test. The self-efficacy questionnaire consisted of five items. On a scale from 1 ("not confident at all") to 10 ("extremely confident"), participants rated their confidence that they would be able to achieve an average score of zero, one, two, three, four, or five points, respectively. Before the practice phase, participants were asked to indicate their confidence with respect to their performance on the last practice block (i.e., trials 41-60). The self-efficacy rating after the practice phase referred to the retention test on the following day, and the final rating before the transfer test was related to their performance on a task that required hitting from a novel distance to the target. Positive and negative affect were assessed at the end of the practice phase. For this purpose, sets of three items were excerpted from the Positive and Negative Affect Schedule – Expanded Form (PANAS-X; Watson & Clark, 1994). Participants were asked to rate each word in terms of the extent to which they felt (a) joyful, (b) confident, (c) concentrating (positive affect), and (d) distressed, (e) ashamed, or (f) irritable (negative affect) during practice on a scale from 1 (very slightly or not at all) to 5 (extremely). Positive and negative affect scores were averaged across the respective items. Cronbach's alpha values were 0.91 (positive affect) and 0.86 (negative affect).

2.4. Data analysis

The accuracy of participants' pitch shots was determined by averaging their scores across blocks of 20 trials. To analyze pretest performance, a one-way analysis of variance (ANOVA) was used. The practice data were analyzed in a 2 (groups: EF, IF) × 3 (blocks) mixed ANOVA with repeated measures on the last factor. The retention and transfer results were each analyzed in one-way analyses of covariance (ANCOVAs) with the pretest score as a covariate. For the self-efficacy ratings before the practice phase, we used a one-way ANOVA, while self-efficacy after practice and before the retention and transfer tests was analyzed in one-way ANCOVAs with the before-practice rating as a covariate. Positive and negative affect were analyzed using one-way ANOVAs. The alpha level was set to a value of 0.05, and partial eta squared (η_p^2) was used to determine effect size.

3. Results

3.1. Accuracy

3.1.1. Pretest

Accuracy scores are shown in Fig. 1. As can be seen, the EF (0.88) and IF (0.98) groups performed similarly on the pretest. There was no significant difference between groups, F (1, 34) = 0.831, p = .369, η_p^2 = .024.

3.1.2. Practice phase

Both groups increased their shot accuracy across the practice phase, with the EF group demonstrating greater accuracy than the IF group (see Fig. 1). The main effect of block was significant, F (2, 68) = 13.83, p < .001, η_p^2 = .289. The Group main effect was also significant, F (1, 34) = 7.175, p = .011, η_p^2 = .174. The EF group (Block 1: 1.25, Block 2: 1.54; Block 3: 1.70) outperformed the IF group (Block 1: 1.13, Block 2: 1.17; Block 3: 1.32) on all three blocks. As can be seen in Fig. 1, the performance advantage for the EF relative to the IF group increased on the second and third blocks relative to the first block of practice. The interaction of group and block reached borderline significance, F (2, 68) = 3.064, p = .053, η_p^2 = .083.

3.1.3. Retention test

On the retention test conducted one day after the practice phase, the EF group (1.56) had higher accuracy scores than the IF group (1.16). The group difference was significant, F (1, 33) = 18.189, p < .001, η_p^2 = .355.

3.1.4. Transfer test

On the transfer test from a longer distance to the target (13 m), the EF group (1.24) again showed greater accuracy than the IF group (1.01). The group difference was significant, F (1, 33) = 8.186, p < .01, η_p^2 = .199.

3.1.5. Manipulation check

The manipulation check indicated that both groups used the instructed attentional foci to a relatively high degree. EF group participants reported using the respective foci during practice 81.4% (*SD*: 8.02) of the time, on average (Block 1: 80.5%; Block 2: 81.6%; Block 3: 82.1%). In the IF group, participants indicated that they adopted the instructed attentional foci to a similar degree, namely, 83.5% (*SD*: 9.87) of the time (Block 1: 83.1%; Block 2: 85.8%; Block 3: 81.6%).

3.1.6. Self-efficacy

Self-efficacy ratings are shown in Fig. 2. Before the practice phase, self-efficacy was similar for the EF and IF groups, and there was no significant difference between groups, F (1, 34) = 0.501, p = .484, η_p^2 = .015. After the practice phase, self-efficacy in the EF group tended to be higher than in the IF group, although the Group effect failed to reach significance, F (1, 33) = 2.687, p = .111, η_p^2 = .075. However, one day later, before the retention test, the EF group had significantly higher self-efficacy ratings than the IF group, F (1, 33) = 5.721, p = .023, η_p^2 = .148. With respect to performance from a novel distance on the subsequent transfer test, the EF group's self-efficacy again tended to be higher, but the group difference did not reach significance, F (1, 33) = 2.804, p = .103, η_p^2 = .078.

3.2. Affect

3.2.1. Positive affect

After the practice phase, the EF group had higher positive affect than the IF group (see Fig. 3, left). EF group participants' average positive affect rating was 3.64 (*SD* = 0.83), whereas the IF group's rating was 2.77 (*SD* = 0.86). The group difference was significant, F (1, 34) = 9.529, p = .004, η_p^2 = .219.

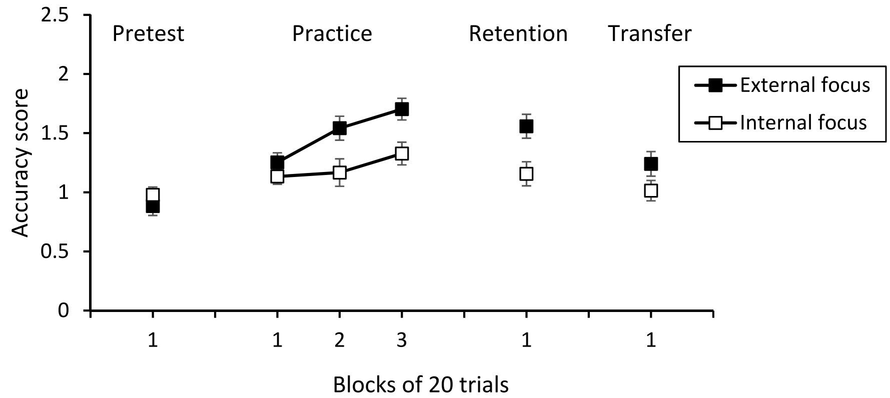

Fig. 1. Accuracy scores (higher scores indicate greater accuracy) for the EF and IF groups during the pretest, practice phase, retention test, and transfer test. Error bars represent standard errors.

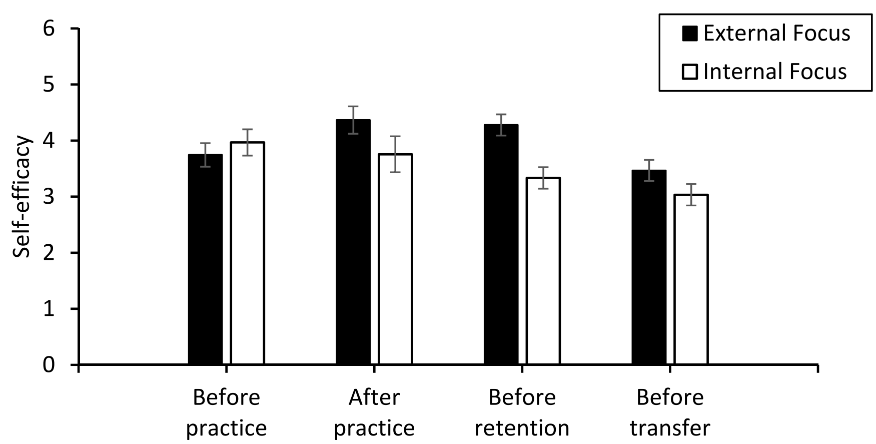

Fig. 2. Self-efficacy ratings of the EF and IF groups before practice, after practice, and before the retention and transfer tests. Error bars represent standard errors.

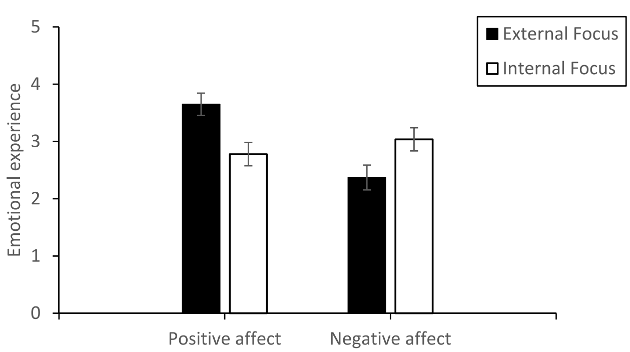

Fig. 3. Positive and negative affect ratings in the EF and IF groups after the practice phase. Error bars represent standard errors.

3.2.2. Negative affect

The EF group reported lower negative affect than the IF group (Fig. 3, right). Average negative affect scores were 2.37 ($SD = 0.92$) for the EF group and 3.04 ($SD = 0.85$) for the IF group. The group difference was significant, F (1, 34) = 5.067, $p = .031$, $\eta_p^2 = .130$.

4. Discussion

The learning of a golf pitch shot was enhanced by instructions that promoted an external relative to an internal focus of attention. In contrast to most attentional focus studies, in which the effectiveness of one external versus internal focus instruction was compared (see Chua et al., 2021), in the present study three focus instructions were given to participants in each group. The instructions were related to movement form (i.e., swing distance, swing weight) as well as the appropriate parameterization (i.e., performance outcome). The focus instructions were provided at different times during the practice phase (i.e., on different blocks of 20 trials), and their order was counterbalanced so that each instruction was given the same number of times during the first, second, or last third of the practice phase. The external focus advantage in shot accuracy was already seen throughout the practice phase when the instructions were given, with the group difference tending to increase with continued practice. Importantly, the superior performance resulting from the external focus instructions was also seen on delayed tests of learning. One day after the practice phase, the external focus group outperformed the internal focus group on a retention test involving the same target distance (10 m) as that used during practice. In addition, performance on the transfer test that involved a new target distance (13 m) was enhanced, demonstrating the generalizability of the learning benefits of an external focus to novel situations. These findings corroborate the findings seen in previous studies, for both retention and transfer performance (see Chua et al., 2021).

The manipulation checks indicated that participants mostly (i.e., more than 80% of the time) adopted the instructed attentional foci. These results are similar to those of previous studies in which manipulation checks were used (e.g., Bell & Hardy, 2009; Kearney, 2015; Land, Tenenbaum, Ward, & Marquardt, 2013). Thus, despite occasional lapses, participants generally followed the instructions and focused on what they are asked to concentrate on, and it was sufficient to affect their learning outcomes.

An external focus is assumed to contribute to the fluidity with which the movement goal is translated into neuromuscular activation, or *goal-action coupling* (Wulf & Lewthwaite, 2016; see also Lewthwaite & Wulf, 2017; Wulf & Lewthwaite, 2021). This includes the facilitation of functional connectivity among task-related brain networks. It is also reflected in reduced activity in unrelated or self-related networks, similar to what is typically seen in expert performers (Giboin, Loewe, Hassa, Kramer, Dettmers, Spiteri, Gruber, & Schoenfeld, 2019; Milton, Solodkin, Hluštík, & Small, 2007). An external focus is assumed to reduce self-referential processing, or activation of a self-invoking trigger, associated with an internal focus (McKay, Wulf, Lewthwaite, & Nordin, 2015; Wulf & Lewthwaite, 2010). The result of directing attention to the intended movement effect, or task goal, is that movement coordination resembles that typically seen at higher skill levels. With an external focus, motor unit recruitment is more efficient, co-contractions are reduced (Lohse & Sherwood, 2012), and force production is enhanced (e.g., Marchant, Greig, & Scott, 2009). Furthermore, an external focus helps the body take advantage of its degrees of freedom (Wulf & Dufek, 2009), as indicated by increased functional variability (Singh et al., 2022), with the consequence that movement accuracy is enhanced.

From the pretest to end of the practice phase, the external focus group's average accuracy scores increased by 0.82 points, whereas the internal focus group's increased by only 0.35 points. The greater movement success experienced by participants in the external focus group should enhance expectancies for future success, according to an OPTIMAL theory prediction (Wulf & Lewthwaite, 2016, Prediction 6, p. 1404). Our self-efficacy data provided support for this assumption. Before the retention test, external focus group participants' self-efficacy ratings were significantly higher than those of internal focus group participants. This is an important finding as it suggests that performance under external focus conditions can be rewarding. Positive experiences or reward are associated with dopamine release (Beeler & Kisbye Dreyer, 2019; Speranza, di Porzio, Viggiano, de Donato, & Volpicelli, 2021). The neurotransmitter dopamine supports efficiencies in brain connectivity and contributes to the consolidation of motor memories (e.g., Sugawara, Tanaka, Okazaki, Watanabe, & Sadato, 2012; Wise, 2004). Thus, the increased self-efficacy, or expectation of future positive outcomes, resulting from good performance with an external focus may provide an additional benefit, namely, by a triggering dopaminergic response that further enhances performance and learning (see Wulf & Lewthwaite, 2016, Predictions 1 and 7, p. 1404).

The experience of successful movement outcomes, or lack thereof, affected learners' emotional responses. At the end of practice, positive affect was significantly higher in the external relative to the internal focus group. Moreover, negative affect was higher in the internal than in the external focus group. It is likely that the positive affect resulting from good performance during practice heightened expectations of a rewarding experience during the retention test. Positive affect is associated with phasic increases in dopamine discharge that strengthen neural connections (Ashby, Turner, & Horvitz, 2010), and it is also believed to play a role in consolidating motor memories (Trempe, Sabourin, & Proteau, 2012). Positive affect and self-efficacy expectations may have been co-effects of the same positive experience of good practice performance with an external focus (see Wulf & Lewthwaite, 2016, p. 1388). However, it is also possible that the positive affect experienced during and/or after practice played an additional role in the learning benefits seen with an external focus (Young & Nusslock, 2016).

Overall, the present findings provide several important insights, with implications for theory and practice. First, the performance benefits resulting from an external focus during practice had motivational consequences. Compared to internal focus participants, external focus participants experienced greater positive affect and reported greater confidence in their ability to perform well on the retention test. These influences may have further enhanced learning in external focus participants – potentially resulting in a *virtuous cycle* of positive effects for motivation, performance, and learning. Conversely, the limited performance improvements experienced by participants who were asked to adopt a relatively ineffective internal focus may have contributed to their heightened negative affect. The need for self-regulatory processes to manage negative emotional responses (Carver & Scheier, 1978) may have led to further performance impairments (see Wulf & Lewthwaite, 2010) – possibly producing a *vicious cycle* of an increased self-focus, reduced self-efficacy and positive affect, and non-optimal performance and learning (see Wulf & Lewthwaite, 2016, pp. 1405-1406). Thus, the findings of the present study are in line with several assumptions of the OPTIMAL theory. From an applied perspective, they highlight the importance for practitioners, including coaches and athletes, to give instructions and feedback, or use swing thoughts, that promote an external focus of attention. Furthermore, several external focus instructions can be provided in the same practice session – directed at different aspects of the movement and given in any order – to facilitate skill learning.

Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

Data will be made available on request.

References

Abdollahipour, R., Wulf, G., Psotta, R., & Palomo Nieto, M. (2015). Performance of gymnastics skill benefits from an external focus of attention. *Journal of Sports Sciences, 33*, 1807–1813.
An, J., Wulf, G., & Kim, S. (2013). Increased carry distance and X-factor stretch in golf through an external focus of attention. *Journal of Motor Learning and Development, 1*, 2–11.
Ashby, F. G., Turner, B. O., & Horvitz, J. C. (2010). Cortical and basal ganglia contributions to habit learning and automaticity. *Trends in Cognitive Sciences, 14*, 208–215.
Beeler, J. A., & Kisbye Dreyer, J. (2019). Synchronicity: The role of midbrain dopamine in whole-brain coordination. *eNeuro, 6*. https://doi.org/10.1523/ENEURO.0345-18.2019
Bell, J. J., & Hardy, J. (2009). Effects of attentional focus on skilled performance in golf. *Journal of Applied Sport Psychology, 21*, 163–177. https://doi.org/10.1080/10413200902795323
Carver, C. S., & Scheier, M. F. (1978). Self-focusing effects of dispositional self-consciousness, mirror presence, and audience presence. *Journal of Personality and Social Psychology, 36*, 324–332.
Christina, R. W., & Alpenfels, E. (2014). Influence of attentional focus on learning a swing path change. *International Journal of Golf Science, 3*, 35–49.
Chua, L.-K., Jimenez-Diaz, J., Lewthwaite, R., Kim, T., & Wulf, G. (2021). Superiority of external attentional focus for motor performance and learning: Systematic reviews and meta-analyses. *Psychological Bulletin, 147*, 618–645.
Chua, L.-K., Wulf, G., & Lewthwaite, R. (2018). Onward and upward: Optimizing motor performance. *Human Movement Science, 60*, 107–114.
Feltz, D. L., Chow, D. M., & Hepler, T. J. (2008a). Path analysis of self-efficacy and diving performance revisited. *Journal of Sport & Exercise Psychology, 30*, 401–411.
Giboin, L. S., Loewe, K., Hassa, T., Kramer, A., Dettmers, C., Spiteri, S., … Schoenfeld, M. A. (2019). Cortical, subcortical and spinal neural correlates of slackline training-induced balance performance improvements. *NeuroImage, 202*, Article 116061. https://doi.org/10.1016/j.neuroimage.2019.116061
Greig, M., & Marchant, D. (2014). Speed dependant influence of attentional focusing instructions on force production and muscular activity during isokinetic elbow flexions. *Human Movement Science, 33*, 135–148.
Hutchinson, J. C., Sherman, T., Martinovic, N., & Tenenbaum, G. (2008). The effect of manipulated self-efficacy on perceived and sustained effort. *Journal of Applied Sport Psychology, 20*, 457–472.
Jenkins, G., & Walton, M. (2020). Dopamine: Don't underestimate the force. *Current Biology, 30*, R802–R830.
Kal, E. C., van der Kamp, J., & Houdijk, H. (2013). External attentional focus enhances movement automatization: A comprehensive test of the constrained action hypothesis. *Human Movement Science, 32*, 527–539.

Kearney, P. E. (2015). A distal focus of attention leads to superior performance on a golf putting task. *International Journal of Sport and Exercise Psychology, 13*, 371–381. https://doi.org/10.1080/1612197X.2014.993682
Kim, T., Jimenez-Diaz, J., & Chen, J. (2017). The effect of attentional focus in balancing tasks: A systematic review with meta-analysis. *Journal of Human Sport and Exercise, 12*, 463–479.
Kuhn, Y. A., Keller, M., Egger, S., & Taube, W. (2021). Effects of an external compared to an internal focus of attention on the excitability of fast and slow(er) motor pathways. *Scientific Reports, 11*, Article 17910.
Kuhn, Y. A., Keller, M., Lauber, B., & Taube, W. (2018). Surround inhibition can instantly be modulated by changing the attentional focus. *Scientific Reports, 8*, 1085.
Land, W. M., Tenenbaum, G., Ward, P., & Marquardt, C. (2013). Examination of visual information as a mediator of external focus benefits. *Journal of Sport & Exercise Psychology, 35*, 250–259. https://doi.org/10.1123/jsep.35.3.250
Lewthwaite, R., & Wulf, G. (2017). Optimizing motivation and attention for motor performance and learning. *Current Opinion in Psychology, 16*, 38–42.
Lohse, K. R. (2012). The influence of attention on learning and performance: Pre-movement time and accuracy in an isometric force production task. *Human Movement Science, 31*, 12–25.
Lohse, K. R., & Sherwood, D. E. (2012). Thinking about muscles: The neuromuscular effects of attentional focus on accuracy and fatigue. *Acta Psychologica, 140*, 236–245.
Lohse, K. R., Wulf, G., & Lewthwaite, R. (2012). Attentional focus affects movement efficiency. In N. J. Hodges, & A. M. Williams (Eds.), *Skill acquisition in sport: Research, theory & practice* (2nd ed., pp. 40–58). London: Routledge.
Manohar, S. G., Chong, T. T.-J., Apps, M. A. J., Batia, J., Stamelou, M., Jarman, P. R., Bhatia, K. P., & Husain, M. (2015). Reward pays the cost of noise reduction in motor and cognitive control. *Current Biology, 25*, 1707–1716.
Marchant, D. C. (2011). Attentional focusing instructions and force production. *Frontiers in Psychology, 1*. https://doi.org/10.3389/fpsyg.2010.00210. Article 210.
Marchant, D. C., Greig, M., & Scott, C. (2009). Attentional focusing instructions influence force production and muscular activity during isokinetic elbow flexions. *The Journal of Strength & Conditioning Research, 23*, 2358–2366.
McKay, B., Wulf, G., Lewthwaite, R., & Nordin, A. (2015). The self: Your own worst enemy? A test of the self-invoking trigger hypothesis. *Quarterly Journal of Experimental Psychology, 68*, 1910–1919.
Milton, J., Solodkin, A., Hluštík, P., & Small, S. L. (2007). The mind of expert motor performance is cool and focused. *NeuroImage, 35*, 804–813.
Park, S. H., Yi, C. W., Shin, J. Y., & Ryu, Y. U. (2015). Effects of external focus of attention on balance: A short review. *Journal of Physical Therapy Science, 27*, 3929–3931.
Parr, R., & Button, C. (2009). End-point focus of attention: Learning the "catch" in rowing. *International Journal of Sport Psychology, 40*, 616–635.
Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review, 82*, 225–260.
Singh, H., Shih, H.-T., Kal, E., Bennett, T. B., & Wulf, G. (2022). A distal external focus of attention facilitates compensatory coordination of body parts. *Journal of Sports Sciences*. https://doi.org/10.1080/02640414.2022.2150419
Speranza, L., di Porzio, U., Viggiano, D., de Donato, A., & Volpicelli, F. (2021). Dopamine: The neuromodulator of long-term synaptic plasticity, reward and movement control. *Cells, 10*, 735. https://doi.org/10.3390/cells10040735
Sugawara, S. K., Tanaka, S., Okazaki, S., Watanabe, K., & Sadato, N. (2012). Social rewards enhance offline improvements in motor skill. *PLoS One, 7*. https://doi.org/10.1371/journal.pone.0048174
Trempe, M., Sabourin, M., & Proteau, L. (2012). Success modulates consolidation of a visuomotor adaptation task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*, 52–60.
Watson, D., & Clark, L. A. (1994). *The PANAS-X: Manual for the positive and negative affect schedule-expanded form.* Iowa City: University of Iowa.
Wise, R. A. (2004). Dopamine, learning, and motivation. *Nature Neuroscience, 5*, 1–12.
Wulf, G. (2007a). *Attention and motor skill learning.* Champaign, IL: Human Kinetics.
Wulf, G. (2007b). Self-controlled practice enhances motor learning: Implications for physiotherapy. *Physiotherapy, 93*, 96–101.
Wulf, G. (2013). Attentional focus and motor learning: A review of 15 years. *International Review of Sport and Exercise Psychology, 6*, 77–104.
Wulf, G., Chiviacowsky, S., & Lewthwaite, R. (2012). Altering mindset can enhance motor learning in older adults. *Psychology and Aging, 27*, 14–21.
Wulf, G., & Dufek, J. S. (2009). Increased jump height with an external attentional focus is due to augmented force production. *Journal of Motor Behavior, 41*, 401–409.
Wulf, G., Höß, M., & Prinz, W. (1998). Instructions for motor learning: Differential effects of internal versus external focus of attention. *Journal of Motor Behavior, 30*, 169–179.
Wulf, G., Lauterbach, B., & Toole, T. (1999). Learning advantages of an external focus of attention in golf. *Research Quarterly for Exercise & Sport, 70*, 120–126.
Wulf, G., & Lewthwaite, R. (2010). Effortless motor learning? An external focus of attention enhances movement effectiveness and efficiency. In B. Bruya (Ed.), *Effortless attention: A new perspective in attention and action* (pp. 75–101). Cambridge, MA: MIT Press.
Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin & Review, 23*, 1382–1414.
Wulf, G., & Lewthwaite, R. (2021). Translating thoughts in action: Optimizing motor performance and learning through brief motivational and attentional influences. *Current Directions in Psychology, 30*, 535–541. https://doi.org/10.1177/09637214211046199
Wulf, G., Lewthwaite, R., Cardozo, P., & Chiviacowsky, S. (2018). Triple play: Additive contributions of enhanced expectancies, autonomy support, and external attentional focus to motor learning. *Quarterly Journal of Experimental Psychology, 71*, 824–834.
Wulf, G., McNevin, N. H., & Shea, C. H. (2001). The automaticity of complex motor skill learning as a function of attentional focus. *Quarterly Journal of Experimental Psychology Section A, 54*, 1143–1154.
Wulf, G., & Prinz, W. (2001). Directing attention to movement effects enhances learning: A review. *Psychonomic Bulletin & Review, 8*, 648–660.
Wulf, G., & Su, J. (2007). An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise & Sport, 78*, 384–389.
Young, C. B., & Nusslock, R. (2016). Positive mood enhances reward-related neural activity. *Social Cognitive and Affective Neuroscience, 11*, 934–944.
Zachry, T., Wulf, G., Mercer, J., & Bezodis, N. (2005). Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Research Bulletin, 67*, 304–309.
Ziv, G., & Lidor, R. (2015). Attentional focus and motor learning in clinical settings and in older age: A review. *Journal of Motor Learning and Development, 3*, 123–139.