OPTIMIZING GOLF SKILL LEARNING

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Introduction

Golf skills are arguably among the most complex sports skills. Although ‘complexity’ is notoriously difficult to define, the high precision requirements involved in hitting a golf ball, coupled with a relatively high clubhead speed, and the countless degrees of freedom involved in a coordinated action of the whole body are criteria that most would probably agree constitute complex skills. Both novice and professional golfers alike know the challenges this sport entails. To assist them in overcoming those challenges, different approaches to teaching have been developed by golf professionals, often based on their own experience and the perceived success of their methods (e.g., Jimmy Ballard, Butch Harmon, and David Leadbetter). For instance, David Leadbetter has built 28 golf academies across 11 countries that promote his methods and drills.

Motor learning researchers are concerned with understanding the factors that influence the learning of motor skills, i.e., that is, relatively permanent changes in motor skill as a result of practice (Schmidt & Lee, 2011). Learning is typically measured by delayed (i.e., 24 hours or more) retention or transfer tests. The knowledge generated through studies that examine the effects of certain variables on skill learning can help practitioners to design effective practice conditions. The understanding of how learning is affected by different types of variables or instructional methods has seen some significant developments over the past few years. Specifically, three factors that are critical for optimal motor learning have been identified, and these are central to a new theory of motor learning, the OPTIMAL (Optimizing Performance Through Intrinsic Motivation and Attention for Learning) theory (Wulf & Lewthwaite, 2016). Two of the key factors are motivational in nature, enhanced expectancies for performance and autonomy support, and one is related to the performers’ attention, an external focus of attention. In this chapter, we review findings related to each factor, with particular consideration for golf-specific studies. We also provide examples of how golf instructors and coaches may incorporate those variables in their work with their clients and athletes.

Enhancing expectancies

Being confident in one’s ability to perform well is critical for optimal motor performance, and this is immediately obvious in golf. Circumstances that enhance learners’ expectancies of future success in golf can potentiate even more success (Rosenqvist & Scans, 2015). Thus, providing
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learners with a heightened sense of confidence, or self-efficacy, is key to effective long-term changes in performance (i.e., learning) and sustained performance at a higher level. Expectancies for performance can be enhanced in various ways. In the motor learning literature, different manipulations have been used to increase learners' performance expectancies. For example, in several studies, feedback was provided on trials with relatively small errors versus larger errors (e.g., Chiviacowsky & Wulf, 2007; Clark & Ste-Marie, 2007; Chiviacowsky et al., 2009; Saemi et al., 2012). Even though, intuitively, one might expect feedback to be more effective when it is provided after less successful trials, in studies, learning was consistently facilitated when feedback was given on more accurate trials. Thus, highlighting good performances and essentially ignoring poor trials resulted in higher self-efficacy (e.g., Saemi et al., 2012) and more effective learning than the opposite. Even simple statements suggesting that peers typically do well on a given task (Wulf et al., 2012, Experiment 2), encouraging statements about the learner's performance or aspects of the skill that are performed well, or about general improvement (Wulf et al., 2010) will likely suffice to promote learning.

Increasing learners' perceptions of success during practice can be achieved through other means as well. For example, setting criteria that purportedly indicate good performance, but that can be reached relatively easily, can raise learners' expectancies and facilitate learning. In a study by Trempe et al. (2012), the learning of a visuo-motor task was enhanced when participants were given a relatively easy goal compared with a more difficult goal. Participants with the easy goal achieved that goal more frequently, and thus experienced more success during the practice phase, than did those with the difficult goal. When the groups were retested the next day (retention test), the easy-goal group performed more accurately than the difficult-goal group. Thus, after memory consolidation had a chance to take place (i.e., 24 hours later), the success experienced during practice in the former group manifested itself in enhanced learning.

Mechanisms underlying the enhanced expectancy effect

High performance expectancies prepare the mover for successful movement at cognitive, motiva-
tional, neurophysiological, and neuromuscular levels. This ensures that goals are effectively coupled with desired actions – termed goal-action coupling in the OPTIMAL theory (Wulf & Lewthwaite, 2016). Enhanced expectancies may also serve as a buffer against responses that would detract from optimal performance, such as distracting thoughts or self-referential thinking (refer section on External focus of attention).

Golf-specific studies

A few studies have demonstrated how enhancing performance expectancies can lead to more effective learning of golf skills. In one study, novice golfers performed a putting task where the target was surrounded by two concentric circles (Palmer et al., 2016). One group was instructed that putting within the larger circle would constitute 'good' golf puts, whereas another group was informed that balls ending up in the smaller circles would be considered 'good' puts. The group for whom the larger circle was identified had smaller deviations from the target in practice than did the group with the higher standard definition of success (smaller circle). More importantly, in delayed retention and transfer tests, with the circles removed, these group differences were maintained. Thus, making learners feel successful during practice resulted in more effective learning. Enhanced performance expectancies likely also play a role in other interventions designed to allow learners to experience success. Putting practice with increasing distances from the hole, sometimes
called “errorless” practice (Maxwell et al., 2001), has been shown to result in fewer putting errors relative to putting with increasing distances (‘errorful’ practice), as well as improved retention test performance (for similar results with older adults, refer Chauvel et al., 2012).

Visual illusions affecting the perceived size of the hole can also influence accuracy in golf putting. In a few studies (Witt et al., 2012; Wood et al., 2013; Chauvel et al., 2015), the golf hole was surrounded either by larger circles, making the hole appear smaller, or by small circles, making the hole appear larger (Ebbinghaus illusion). As first demonstrated by Witt et al. (2012), when the golf hole appeared larger, participants produced more accurate puts than when the hole was surrounded by larger circles (refer also Wood et al., 2013). In a follow-up study, Chauvel et al. used a delayed retention test to determine whether the performance-enhancing effects would be relatively permanent and independent of the presence of the visual illusions. Learning was indeed enhanced in the group that practiced with a perceived larger hole compared with a group that experienced a smaller-looking hole. Moreover, in the group with the perceived larger hole, self-efficacy was higher. Thus, enhancing learners’ performance expectancies by making the hole appear larger resulted in more effective learning of the putting task. Overall, it is striking how easily performance and learning can be affected by performers’ expectancies.

**Implications for golf**

These findings have important implications for coaching. They suggest that it may be helpful for coaches to reconsider a number of factors that are considered standard practice in coaching. These include the predominance of offering feedback on unsuccessful trials instead of successful ones, or how they set up challenges for pupils with regards to task difficulty. For example, with beginners, there is often an emphasis on wanting to hit the ball a reasonable distance early in the learning process. For a coach, creating a distance goal that is relatively easy, coupled with enhanced expectancy of what is deemed to be acceptable at that stage of learning, can have a significant impact on early success experience. When setting challenges that involve accuracy, e.g., in short game or putting, coaches will often use tees or markers to demarcate the target zone for a pupil. In order to evoke greater learning and performance, coaches could consider making these tasks easier and lower the challenge level that they normally set in the future. Furthermore, the findings have implications for bringing beginners into the game. With the number of new participants in golf dropping (Sports Marketing Surveys, 2015) and one of the reasons cited for this being the perceived difficulty of the game (Syngenta, 2014), the ability for coaches to lower this barrier to entry through early success cannot be understated. Enhanced performance expectancies are also critical for golfers practicing for, or warming up before, a competition. Setting simple and attainable goals during the warm-up, e.g., can serve to boost confidence. Moreover, after a successful putt, not putting again from the same location, or ending the warm-up with a successful shot, can help players enhance their expectancies for performance in the tournament.

**Autonomy support**

Autonomy support is another motivational variable that appears to be indispensable for optimal learning (Wulf & Lewthwaite, 2016). The need to be autonomous, i.e., being able to make one’s own choices, is considered a fundamental psychological need (e.g., Deci & Ryan, 2008). Conditions that support individuals’ need for autonomy have been shown to increase motivation, performance, or learning in a variety of situations (e.g., Reeve & Tseng, 2011). In the motor learning literature, practice conditions in which learners are allowed to make certain decisions themselves - tend to have beneficial effects on learning. For instance, giving learners (e.g., Janelle et al., 1997; Wulf, 2007; Wulf, 2007), or choosing to enhance learning. In some other studies (e.g., Chauvel et al., 2014) varied the way in which instructions that gave them to superior learning than other (controlling language).

The motivational nature of learners’ need for autonomy and in accordance with their need to find ways to facilitate learning a study by Wulf and Adey. In a choice group, they perform those tasks. In the study, by what their autonomy showed superior balance out the practice phase and the tasks. Thus, the ability to choose what to learn.

In another study (Wulf & Adey, 2012) subsequently chose to consider this. Thus, an additional benefit of this study is that it is even more striking that to be learned has been understood. In one experiment (Lewthwaite et al., 2014) a group in which participants, afterwards, and in which the task was hung in the laboratory. For example, or the picture to be hung in the laboratory. These findings demonstrate the potential of autonomy not directly related to the task.

**Mechanisms**

Potential consequences of autonomy support in enhanced processing of the task (Wulf & Adey, 2013). Moreover, some participants who were allowed to choose conditions (McGraw et al., 2012) reported being able to choose whether to enhance expectations for feedback typically reported that they were more successful (e.g., Chiviacowsky et al., 2012). The goal–action coupling by
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decisions themselves – termed self-controlled practice – have consistently been shown to have beneficial effects on learning relative to control conditions (for reviews, refer Wulf, 2007). For instance, giving learners the opportunity to request feedback when practising a motor task (e.g., Janelle et al., 1997), letting them decide when to use an assistive device (e.g., Hartman, 2007; Wulf, 2007), or choose the number of practice trials (Post et al., 2014) has been shown to enhance learning. In addition, the type of instructional language (i.e., autonomy supportive versus controlling) has been found to have an impact on motor learning. Hooyman et al. (2014) varied the way in which instructions for performing a novel motor task were presented. Instructions that gave the learners a sense of choice (i.e., autonomy-supportive language) led to superior learning than instructions that offered little option for how to execute the skill (i.e., controlling language).

The motivational nature of these effects – i.e., choices contributing to the satisfaction of learners’ need for autonomy – was first highlighted by Lewthwaite and Wulf (2012). Interestingly, and in accordance with this view, even minor and seemingly insignificant choices have been found to facilitate learning (e.g., Wulf et al., 2014a; Lewthwaite et al., 2015). For example, in a study by Wulf and Adams (2014), participants were asked to perform three different balance tasks. In a choice group, participants were allowed to choose the order in which they wanted to perform those tasks. In the control group, each participant’s order was determined, unbeknown to them, by what their assigned counterpart in the choice group had selected. The choice group showed superior balance performance on all tasks, compared with the control group, throughout the practice phase and, more importantly, on a delayed retention test with a fixed order of tasks. Thus, the ability to choose the task order during practice enhanced balance learning. In another study (Wulf et al., 2014b), participants who were able to choose the order of tasks subsequently chose to complete more sets and repetitions than did control group participants. Thus, an additional benefit of giving learners choices is that it can increase their motivation to practise – which might have additional indirect benefits for learning.

It is even more striking that giving individuals choices that are incidental to the motor task to be learned have been shown to have a positive effect on learning (e.g., Wulf et al., 2014a). In one experiment (Lewthwaite et al., 2015, Experiment 2), balance learning was enhanced in a group in which participants were given a choice related to another task they would practice afterwards, and in which they were asked their opinion as to which of two pictures should be hung in the laboratory. Relative to a control group that was simply informed of the second task or the picture to be hung, the choice group demonstrated more effective learning of the balance task. These findings demonstrate that giving learners choices – even small ones or ones that are not directly related to the task – has the capacity to facilitate motor skill learning.

Mechanisms underlying the autonomy support effect

Potential consequences of autonomy support include facilitation of performance through enhanced processing of task errors and greater self-regulatory responsiveness (Legault & Inzlicht, 2013). Moreover, some evidence for a beneficial reduced self-focus comes from findings that participants who were able to choose when to use a balance pole on a balance task (Chiviacowsky et al., 2012) reported being less nervous than participants who were also able to use the pole but could not choose when to use it. Indirect effects of autonomy support include the opportunity to enhance expectations for performance. For example, learners able to control the delivery of feedback typically report asking for feedback when they assumed their performance was relatively successful (e.g., Chiviacowsky & Wulf, 2002). Thus, autonomy support seems to contribute to goal-action coupling by enhancing performance expectancies (Wulf & Lewthwaite, 2016).
Golf-specific studies

Choices as trivial as the colour of objects to be used (e.g., ball colour) have been shown to lead to more effective motor learning (e.g., Wulf et al., 2014a). This includes one study (Lewithwaite et al., 2015, Experiment 1) in which allowing novice golfers to choose the colour of golf balls led to more effective learning of a putting task than not giving them that choice. More specifically, in the choice group, learners were able to choose the golf ball colour (white, orange, or yellow) before each 10-trial block during the practice phase, which consisted of 60 trials. In a control group, learners were provided balls of the same colour that an assigned counterpart in the choice group had used. Choice of ball colour resulted in superior learning, as measured by a retention test 1 day later, in which both groups had to use white balls. Thus, simply being able to choose the colour positively affected learning.

Implications for golf

The effects of autonomy support have considerable implications for golfers and coaches. Throughout the pupil–coach relationship, the coach has many opportunities to support pupils' need for autonomy, thereby affecting their learning. For example, a coach can allow the pupil to choose which target to aim at, in which order to work on the agreed tasks for the coaching session, or which section of the practice field to hit from. When offering augmented feedback, a common tool used by coaches is video replay and, more recently, launch monitors. Coaches can offer choice as to whether a pupil looks at good or bad trials, as well as how frequently they look at them. Furthermore, when asking the pupils to hit clubs in a random order, the pupil could be given a choice as to the order of clubs. When golfers are practicing or performing certain shots (e.g., chip shot), leaving the choice of the club to be used from a specific location up to the player may lead to better outcomes than prescribing the club. Similarly, letting a player decide on the strategy with which he or she wants to play a certain hole may be more effective than trying to dictate the strategy. For coaches working with teams of players, offering choice to players on things such as team order, selection of playing partners, the amount of time needed to warm up, and even incidental choice such as team colours also appear to provide an opportunity for enhanced learning and performance.

External focus of attention

As most golfers will be able to attest, their attentional focus plays a key role in performance. Indeed, an individual's focus of attention, or concentration, is a critical variable in any complex motor activity. However, the need for high precision in golf (e.g., hitting the sweet spot of the clubhead) typically makes the consequences of a less-than-optimal attentional focus immediately obvious. Over the past 2 decades, many studies have shown that adopting an external focus, i.e., concentrating on the intended movement effect (e.g., on the environment), enhances motor performance and learning compared with an internal focus on body movements (e.g., Wulf et al., 1998; for a review, refer Wulf, 2013). An external focus might be one that is directed at the motion of an implement (e.g., racquet, ball, ski, discus, or kayak), even a sticker attached to the body (e.g., chest), a target, the force exerted against the ground, or an image such as the pendulum-like motion of a golf club. Compared with an internal focus (e.g., arms, shoulders, hips), an external focus enhances movement effectiveness (e.g., movement accuracy, consistency) and efficiency (as measured by force production, muscular activity, heart rate, and oxygen consumption) wide variety of skills, ranging, kayaking, and age, or (dis)ability. In the external focus, a free throw that, by reliably producing external attentional focus, thus providing another way to play golf.
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have been shown to lead to the colour of golf balls that choice. More specific colour (white, orange, or green) of 60 trials. In a assigned counterpart in learning, as measured by a Thus, simply being able

Mechanisms underlying the external focus effect

An external, relative to an internal, focus appears to have a dual advantage by (a) directing attention to the task goal and (b) reducing a self-focus (for more details, refer Wulf & Lewthwaite, 2016). Therefore, an external focus is another important contributor to goal–action coupling (Wulf & Lewthwaite, 2016). The result of adopting an external focus is higher automaticity (Wulf et al., 2001) as indicated, e.g., by an increased use of fast, reflexive movement adjustments (Wulf et al., 2001), more effective dual-task performance, and greater movement fluidity (e.g., Kal et al., 2013). A focus on movement effects that occur at a greater distance from the body – and are presumably more easily distinguishable from body movements – result in even greater automaticity (Wulf, 2013). In contrast, an internal focus facilitates access to the self (McKay et al., 2015) and presumably results in ‘micro-choking’ episodes (Wulf & Lewthwaite, 2010), i.e., widespread, inefficient activation of the muscular system, disruption of automaticity, and the use of more conscious control of movements. The consequence is a constrained movement pattern that can be seen when a basketball player ‘short-arms’ a free throw, or when a golfer leaves a putt short. Finally, it should be noted that, by reliably producing more successful performance outcomes and ease of movement, an external attentional focus contributes to enhanced expectancies (e.g., Shafizadeh et al., 2013) – thus providing another indirect advantage for learning.

Golf-specific studies

Several studies have examined the effects of different attentional foci in golf. In the first study, Wulf et al. (1999) used a pitch shot to compare learning in different groups of novices who were asked to focus on either the swing of their arms (internal focus) or the swing of the club (external focus). On a retention test, the external focus group demonstrated greater accuracy in hitting a target than the internal focus group. Those findings were later extended by Wulf and Su (2007, Experiment 1), who found that the same external focus instructions were more effective not only relative to the internal focus instructions, but also relative to no focus instructions (control group). In a second experiment by Wulf and Su, highly skilled golfers with an average handicap of zero were asked to adopt the same foci (internal, external, and control). The golfers completed 20 shots under each of the three focus conditions. Interestingly, these experts also showed the greatest accuracy when they were asked to focus on the club motion (external). Focusing on their arms (internal) and even adopting their typical focus (control condition) resulted in similar and reduced accuracy.

To examine the distance effect, Bell and Hardy (2009) compared the performance of skilled golfers under three focus conditions, namely, the wrist (internal), clubface (proximal external), and the intended ball trajectory and landing point (distal external). As predicted, participants demonstrated the greatest accuracy in hitting a target in the distal external, followed by the proximal external, followed by the internal focus condition. In addition, the performance advantage seen with a distal focus was maintained under pressure (e.g., evaluation by a PGA professional, publication of scores, possibility of winning a prize).
Two recent studies examined the effects of attentional focus instructions on the learning of movement form in golf (An et al., 2013; Christina & Alpenfels, 2014). In the An et al. (2013) study with novice golfers, the instructions were aimed at increasing the angle between the shoulders and pelvis during the downswing – a characteristic of skilled performance – which can be achieved by encouraging a forward weight shift. External focus instructions to ‘push against the left side of the ground’ resulted in a greater increase in that angle on a delayed retention test than did internal focus instructions to shift their weight to the left foot, or no focus instruction (control group) (Figure 8.1a). Importantly, the carry distance of the ball was increased by the external focus instruction as well (Figure 8.1b). Thus, a single external focus instruction enhanced both movement form and outcome. Christina and Alpenfels (2014) recently showed that experienced golfers learned to change their swing path more effectively with external rather than internal focus instructions. In two studies, using a six-iron in Study 1 and a driver in Study 2, the authors showed that an inside-out swing path was retained best with an external focus of attention cue.

![Graph showing angle and distance](image)

**Figure 8.1** Results of the study by An et al. (2013). Different groups of novice golfers hit golf balls under external focus, internal focus, or control conditions (refer text for more details). The practice phase (not shown here) included 100 trials. The pre-test and retention test (after 3 days) consisted of 10 trials each.

Source: Adapted from An et al. 2013, p. 6.
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Implications for golf

For coaches, making use of external cues consistently will improve both the ability to make changes in movement form and facilitate improvements in performance more rapidly. Challenges coaches may face in implementing these small changes in how their coaching cues are delivered will be familiarity but also the creativity to devise relevant tasks and metaphors that draw their pupils to the movement effect rather than the movement itself. For example, when using video feedback, a coach might feel that a faulty hip or shoulder action may be the primary contributor to poor movement form, and it is often easiest to simply ask the pupil to focus on that. However, focusing on the movement of the club or on hitting a certain part of the golf ball may be an alternative cue that will facilitate the change in hip movement required. For coaches working with elite-level players, using external cues effectively can yield considerable gain, particularly, when taking advantage of the distance effect by emphasizing distal attentional cues such as the target or flight of the ball. In preparing elite players for competition, training them to understand their most relevant and meaningful cues, and then ensuring that this becomes part of their pre-tournament preparation, can offer competitive golfers a performance advantage. On the course, it is often recommended that player not think about the swing (e.g., technical modifications to work on during practice). However, elite players are able to use 'technical keys' (e.g., images) on the course to ensure the implementation of technical changes without using internal cues. Using external swing thoughts that are more distal in nature and that are focussed tightly on the movement effect, such as 'hit a high draw', 'land it pin high', or 'start it on the tree on the left', allows the player to maintain the technical aspects during the swing (e.g., try to keep the clubhead moving down the target line after impact) without disrupting automaticity. Many coaches also use various training aids to enhance performance. Rather than using them to merely to try and force the learner into a desired position, the attentional focus findings give coaches a new perspective for their use (i.e., how to use a certain training aid to help the learner understand the desired movement effect even more clearly).

Summary and future directions

We have discussed three factors for motor skill learning that are central to a new theory of motor learning, the OPTIMAL theory (Wulf & Lewthwaite, 2016): enhanced expectancies, autonomy support, and an external focus of attention. The importance of each factor for enhancing performance and learning has been demonstrated in numerous studies, including golf-related studies. While each of these variables plays an important role in and of itself, recent findings show that they have additive effects (Wulf et al., 2014a; Pascua et al., 2015; Wulf et al., 2015), with the presence of all three variables leading to the most effective learning outcomes (Wulf et al., 2017). Golf coaches can easily take advantage of these effects. They require little more than small changes in the way they give instructions or feedback — and, of course, some creativity. Giving their clients (small) choices, delivering feedback at their request, providing success experience, avoiding references to body movements, and instead directing their attention externally can go a long way in terms of facilitating learning. The resulting movement success may even create a virtuous cycle, with overall positive consequences for learning, motivation, and participation in the game of golf.

References


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