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Optimizing Practice for Performance Under Pressure

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The purpose of this paper is to explain the science behind motor skill learning and describe a specific method for optimizing the learning and performance of golf. *The Challenge Point Framework for Motor Learning* (Guadagnoli & Lee, 2004) is used as the basis to describe the process of learning a new skill, and is used to describe how this process can be significantly increased, specifically as it pertains to golf. Strategies are prescribed that will serve to enhance the stress-resistant learning that properly planned and executed practice can afford. This paper focuses on the practice method of contextual interference relative to *Challenge Point Framework*.

Keywords: golf, practice, pressure, performance

> "Every golfer I know wants to be better than they are. In fact, the desire to improve is one of the great draws, and at times great frustration of the game. It doesn't matter if you are a tour pro or a high handicapper, where you are isn't where you want to be"—Excerpt from *Practice to Learn, Play to Win*

Most people believe that their problems with golf start on the course, but in most cases, the problem starts well before they ever get to the first tee. Great golf doesn't start with how you play, but how you practice. In other words, how you play on the course is the result of how you practice off the course. Unintentionally, most people practice to optimize their performance on the range rather than their later performance on the course. Through this article, we discuss this relationship and how you can use recent information in the sciences of motor learning and cognitive neuroscience to create learning that is fast and stress-resistant (i.e., learning that hold up in times of stress or pressure). There are many variables that can be

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manipulated to optimize practice for learning. In this paper we will concentrate on two specific variables: contextual interference and challenge.

Motor Learning, Practice, and Contextual Interference

Since the late 1800s, scientists have studied the acquisition of skill (Bryan & Harter, 1897), but more than 80 years pass between these initial studies and a systemic investigation into the learning effects arising from differing practice schedules. One example comes from Shea and Morgan (1979), who were the first of many to describe what has now become known as the *contextual interference effect*. Contextual interference is a term used to describe the interference that results from practicing a variety of tasks or versions of a task within the context of a single practice situation. A low degree of contextual interference can be established by having the performer practice one task repeatedly within a block of trials (i.e., blocked practice). Higher levels of contextual interference can be established by practicing several tasks in a random order (i.e., random practice). In their landmark study, Shea and Morgan established a key finding in motor learning research: Blocked practice tends to lead to better performance during practice, but a greater degree of learning results from random practice. Learning, in this case, is seen as performance sometime after practice is completed. Essentially, Shea and Morgan's results can be interpreted to suggest that repetitive practice will yield good performance on the range but will not transfer well to the course. One natural interpretation of this effect is that the benefits of simple repetition in the practice setting are short-lived and provide little more than a false sense of security when abilities are later put to the test. These results have been confirmed repeatedly in the literature and across a wide variety of laboratory-based studies (for reviews, see Brady, 1998, Magill & Hall, 1990).

From the Laboratory to the Applied-Setting (i.e., the course)

As is the case with most research within the domain of human performance, quite often we find ourselves trying to make the leap from the laboratory to the real world. The temptation is to assume that what works in the laboratory will transfer to the golf course (or other applied setting). However, some caution must be taken here. Many laboratory-based motor learning studies employ tasks that, while unusual and challenging (e.g., curve tracing or discrete sequences), do not come close to approaching the physical challenge of a full golf swing much less the psychological impact of having to perform such a movement under pressure. Thankfully for our purposes, a growing number of researchers are focusing their experiments on more applied, naturalistic settings. There are now many examples of studies in the literature that have validated the early contextual interference work, showing, for example, the beneficial effects of random practice with skilled baseball players in batting (Hall, Domingues, & Cavozos, 1994) and in field hockey players (Cheong, Lay, Grove, Medic, & Razman, 2012).

The application of contextual interference principles to the game of golf has also seen increasing interest in recent years. While tending to focus primarily on the skill of putting, studies are now confirming that moving beyond repetitive blocked practicing is a key to better performance, particularly where more highly skilled players are concerned. For example, Guadagnoli, Holcomb, and Weber, (1999) demonstrated that novice subjects who practiced under a blocked protocol (repetitive practice) learned more than novice subjects who practiced under a random protocol (varying task or target). The reciprocal was true for experienced subjects: Experienced subjects who practiced under a random protocol learned more than experienced subjects who practiced under a blocked protocol. Presumably, blocked practice provided the most appropriate challenge for novice performers and random practice provided the most appropriate challenge for experienced performers. From these results it was concluded that for performers in the early stages of learning it is desirable to decrease extraneous challenge. However, as the performer becomes more proficient, more challenge is beneficial. This study clearly demonstrated that efficient learning is based on challenging the performer appropriately, and this means different practice strategies for different levels of ability.

By combining the information we have learned regarding blocked and random practice with a specialized model of motor learning, we can optimize practice and learning which will in turn optimize performance on the course.

Motor Learning Model

In general, the process of learning a new skill or refining an existing skill so that it is repeatable and holds up under pressure, can be significantly increased by using the techniques described in the 2004 paper called, *The Challenge Point Framework for motor learning (*Guadagnoli & Lee, 2004*)*. The Challenge Point Framework (CPF) makes three very specific predictions:

1. Practice performance does not necessarily indicate how much learning is taking place.
2. Challenge point is task and learner specific.
3. The challenge point should change as the learner changes.

1. Practice Performance Does Not Necessarily Indicate How Much Learning Is Taking Place.

It is common for individuals to mistake performance during practice for learning (Kantak & Winstein, 2012). This in turn causes frustration when a golfer performs well on the practice tee but not on the course. Many golfers practice skills repetitively, repeatedly hitting the same shot or putt with little challenge, completing the practice sessions with few errors. Does this lack of error indicate that the learner is perfecting the skill? The short answer is no, and certainly not with the efficiency that the learner could potentially harness. In the higher levels of athletics, efficiency and allowing the skill to stand up under stress becomes crucial to competition. This is known as stress resistant learning. How much stress resistant learning is taking place has been shown to depend on the difficulty of the practice relative to the person who is practicing.

Difficulty during practice exists on a continuum, starting with a task of virtually no difficulty (e.g., 2-foot straight putt), increasing until a task is virtually impossible to complete successfully (e.g., 50-foot double-breaking putt) (see Figure 1).

The relationship between practice performance and task difficulty is fairly obvious: As difficulty increases, performance decreases. However, the relationship between practice performance and tasks difficulty is less important than the relationship between task difficulty during practice and the amount of learning that takes place.

Most people assume that if you are doing well in practice you are learning. This assumption is not necessarily correct. In many cases a decrease in practice performance indicates an increase in learning (see Figure 2). This is such an important point it bears repeating: As practice performance decreases, learning increases, at least sometimes. As we will discuss, learning is a function of appropriately challenging an individual, and the appropriate challenge often leads to struggles during practice.

2. Challenge Point Is Task and Learner Specific.

The CPF focuses on determining the Optimal Challenge Point (OCP). The OCP varies based on the task and learner. The greater the learner's expertise the more challenge they can (and should) handle during practice. This OCP challenges the performer in a way that requires struggle and some degree of failure during practice. It is in fact this challenge that allows learning to happen faster and more effectively.

One of the natural questions based on this statement is: Why don't more people practice with appropriate challenge? There are two basic answers to this question.

Most people believe that they play as they practice. If they are doing well during on the range they assume they will do well on the course. Clearly this is not always the case.

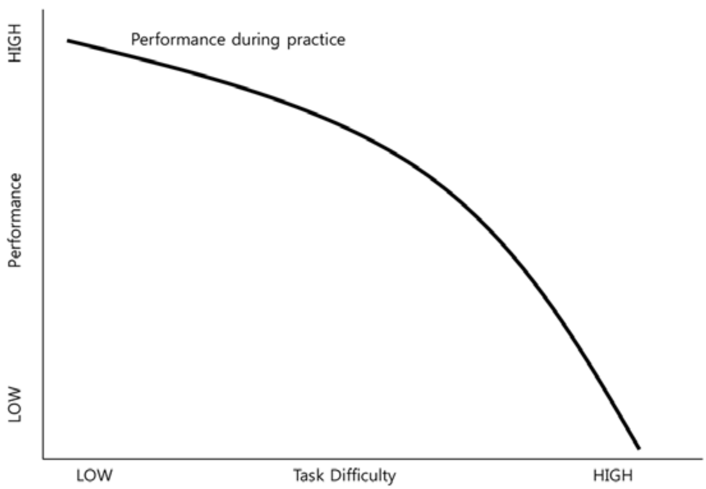

Figure 1 — The relationship between task difficulty and practice performance. The lower the task difficulty the higher the performance during practice.

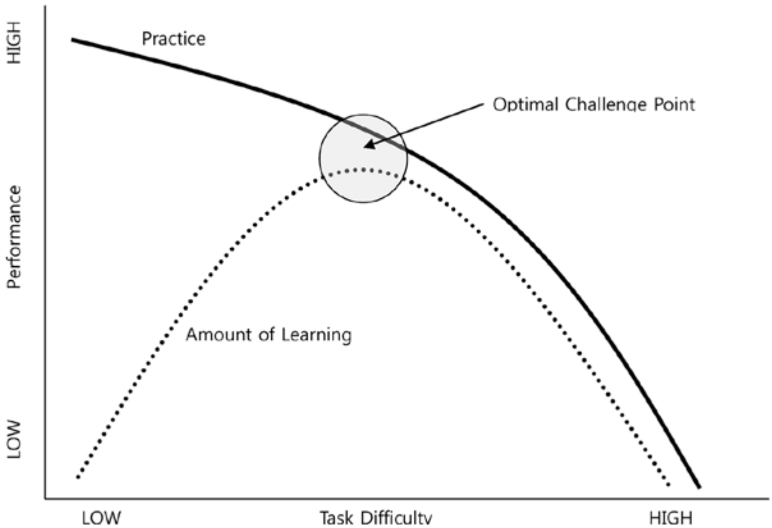

Figure 2 — The relationship between practice performance and retention performance (learning) for differing levels of task difficulty.

It's hard. Setting up practice to challenge oneself is hard. It requires an investment into long-term growth. It doesn't feel as good as hitting several good shots in a row. Most people don't want failure and yet it is the failure on the range that often yields success on the course. Importantly, it is not failure in general that optimizes learning, but appropriate failure. This appropriate failure comes from reaching the OCP.

Once the OCP is determined, a learner can increase ability faster without increasing duration of practice. Therefore, more learning takes place in a shorter amount of time. The trick is to find the OPC for each learner at each stage of learning (see Figure 3).

OCP varies depending upon the complexity of the task, and the skill of the learner. If a task is simple (of low complexity), then the difficulty should be increased to result in an appropriate challenge for the learner. However, if a task is more complex, the challenge may need to be decreased, at least with an inexperienced performer. As we will discuss shortly, there are many factors that impact task difficulty. In regard to putting, for example, the slope, speed, and distance of the putt all contribute to task difficulty. In addition, there are also psychological factors that impact the difficulty of the task, such as the consequence of success and failure.

In addition to being task specific, OCP is also learner specific. This means that if a learner is more experienced in related skills, they will require increased difficulty to illicit an appropriate level of challenge. Conversely, a novice learner will be appropriately challenged by a simpler task.

Over challenging or under challenging will produce inefficient learning. Over challenging will create a high degree of failure which of course is not idea as it tends to demotivate the learner and overwhelms their ability to process information. As a result, little learning takes place. For example, asking a novice

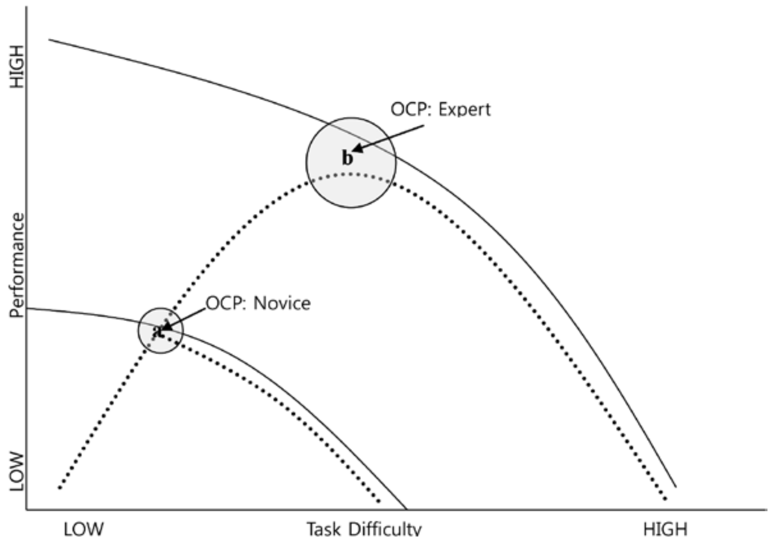

Figure 3 — The relationship between practice performance and retention performance for differing levels of task difficulty and differing levels of performer experience. (a) Represents a performer in the early stage of learning while (b) represents a performer in a later stage of learning.

golfer to hit a 3-wood out of the rough may be too much challenge and simply lead to frustration.

Conversely, under-challenging the player may *feel* good because it produces a great deal of success, but that feeling (and the success) is short-lived. This would be a situation where a skilled golfer practiced hitting twenty 9-irons in a row, from the same perfect lie, to the same target. Of course, the majority of those shots will be hit well, but once that same player steps onto course, that good feeling can quickly turn to frustration when a single 9-iron shot, under pressure, to a tucked pin is not perfectly executed. After the OCP is initially established it needs to be monitored on a regular basis because as the learner changes so too should the way he/she practice. This leads to the third prediction of CPF.

3. The Challenge Point Should Change as the Learner Changes.

Considering OCP is task and learner specific, OCP is dynamic, shifting as a learner increases in proficiency. To account for this shift, practice difficulty should be increased to form an appropriate challenge. Once a learner is proficient in a task, and performance becomes efficient with little failure, learning is no longer optimized at that level of difficulty and should be increased (by virtue of the first and second predictions of CPF).

Once a learner is only making a few mistakes, difficulty should be increased for the player to continue learning efficiently. Indeed, one of the major problems with practice is that players practice the same way regardless of their ability. This strategy may feel good in the short run because of the success during practice, but it leads to long-term frustration on the course.

As noted earlier, as task difficulty increases, the increased challenge will result in more struggles and a decrease in practice performance. This struggle during practice should be anticipated and ideally embraced by players and coaches alike. Learning to embrace challenge and struggle during practice is vital to the process of skill improvement. It takes players outside of their comfort zones and engages those mechanisms required to drive nervous system changes (and ultimately performance gains). If done appropriately, this increased challenge in practice will result in increased performance on the course. Again, performance (i.e., practice performance) does not indicate how much learning is taking place.

With these three predictions, CPF makes it possible to optimize training for a learner of any skill level, and to adapt that program throughout the learning curve to match the changing skill level. Tables 1 and 2 show examples of problems that result from typical practice and what to do about it to optimize learning.

Conclusion

The purpose of the current paper was to overview the science behind motor skill acquisition and describe specific methods for applying contextual interference concepts to golf practice. *The Challenge Point Framework for Motor Learning* (Guadagnoli & Lee, 2004) was used as the basis to describe the process of learning a

Table 1 Practice for High Handicappers.

Typical practice	Problem	Solution
Hit the same club multiple times in a row	Not a problem in the beginning	With high handicappers, hitting several shots with the same club may be ok. Changing clubs too often may add an additional variable and hence too much challenge.
Hit multiple balls in a row (dump the bucket) without a rest/break?	Tempo increases and timing is compromised	Hit no more than 5 balls in a row before taking a break. If you are a mid-range handicapper hit no more than 3 balls in a row.
Hit shots you are comfortable with (lots of 7-irons)	Challenge is too low	As noted above, too much challenge is no good. Changing the club every few cycles of 3–5 balls is good. Make sure that you are challenged but there is a good degree of success (approximately 70% good shots)

Table 2 Practice for Low Handicappers.

Typical practice	Problem	Solution
Hit the same club multiple times in a row	Big problem for the low handicapper because it produces short term success for long term failure	For the low handicappers, hitting several shots with the same club creates a lot of success on the range but and very transfer to the course. The better you are the more often you should change clubs. The single digit handicapper trying to refine their swing should not hit more than 6 balls in a row without changing clubs
Hit multiple balls in a row (dump the bucket) Without a rest/break?	Just like the club, repetition is for short term success not long term learning	Hit no more than 3 balls in a row before taking a break. The general rule is the better you are the fewer balls you should hit in a row and/or with the same club
Hit shots you are comfortable with (lots of 7-irons)	Challenge is too low; golfer starts to get in a groove and stops learning.	As noted, too little challenge is no good. Changing the club every few cycles of 3–6 balls is optimal. Make sure that you are challenged but there is a good degree of success (approximately 70% good shots). Hit shots that are uncomfortable and you will decrease your practice success but increase your learning.

new skill, and was used to describe how this process can be significantly increased. If the idea of appropriate challenge is followed it can help optimize practice time and significantly enhance stress resistant learning (i.e., learning that holds up in times of stress or pressure).

While on the surface many of the ideas discussed in this paper are related to the physical aspect of practice organization, it is important to point out that optimal challenge is about more than improving *movements* per se. While changes in movement quality and consistency are important, so too are the improvements in mental preparedness that appropriate practice routines can achieve. Many people would correctly argue that players at all levels lack the ‘mental’ or psychological preparedness that accompanies that shift from the range to the course. Of course this is true, but it is important to note that mental practice and physical practice are not necessarily mutually exclusive. Adding variability and challenge to a practice regimen engages those cognitive elements that are required to perform on the course and better prepares the learner for the inevitable moment when they need to hit that critical approach shot or make that 6-footer when it matters most.

We would also note that while the sciences of motor learning and cognitive neuroscience have taught us a great deal about better ways to enhance performance, there is undoubtedly still much to learn. For example, while it has been shown, in general terms, that random practice is better for higher skilled players, the story does not end there. For example, there are a myriad of ways to introduce variability or randomness into practice and very little research has been done in this area (and even less within the applied setting of the golf course). There are also a variety of other variables that can be used to change tasks difficulty to optimize challenge for learning. Examples include the use of feedback, the spacing of practice trials, and employing consequence during practice. These issues, in keeping with the central message of this paper, can all be purposely (and purposefully) manipulated to optimize practice and can encourage greater stress-resistant learning, less frustration, and more great golf.

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