THE ROLE OF GOAL SETTING AND AUTOMATICITY IN NOVICE ATHLETES' DEVELOPMENT AND PERFORMANCE OF A TENNIS SKILL: A COACHING INTERVENTION

by

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Abstract

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This dissertation tested the varying branches of research that have explored the issue of automaticity and its relation to goals in sports. One view shows support for a process avoidance perspective on athletic skill development. Another contends that skill development is enhanced when deliberate attention is paid to the execution of a skill's sub-processes. A third social-cognitive view is represented in the current dissertation. This view is reflected in self-regulation theory and suggests that, while both views are valid, the learner must be capable of shifting adaptively from processes to outcomes following extended practice for optimal skill development to occur. Extended attention to processes and attributing errors to strategy are both proposed to represent expert self-regulatory practice methods. Forty novice participants were randomly assigned to one of four groups: a) Extended Process, b) Intermediate Process, c) Self-Shifting, or, d) Outcome Goal. Each group received identical demonstrations of a beginner forehand tennis stroke, followed by sixty attempts at the stroke. *The Extended Process Group* attended to process goals for forty of sixty attempts then shifted to outcome goals for the final twenty attempts. The *Intermediate Process Group* attended to processes for twenty attempts then shifted to outcome goals for the remaining forty attempts. The *Outcome Goal Group* attended to outcomes throughout the sixty attempts. A *Self-Shifting Group* determined for itself when to shift from processes to outcomes. Results generally supported hypotheses, with the *Extended Process Group* outperforming other groups on measures of forehand skill and accuracy, in particular following the final phase of practice.

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CHAPTER ONE

INTRODUCTION

The purpose of this chapter is to provide an overview of automaticity and its role in the development of athletic expertise. I will initially define and present various views of automaticity and its consequences. Research relating metacognitive goal setting to the control of automaticity is then considered. Finally, the purpose and rationale for this dissertation research is presented.

There is growing interest in exploring differences between experts and their non-expert or novice counterparts, ranging across diverse fields such as education, music, board games, and sports (Beilock, Carr, MacMahon, & Starkes, 2002; Cleary & Zimmerman, 2001, 2002; Ericsson, 2006; Harwood, Cumming, & Fletcher, 2003; Kitsantas & Zimmerman, 2002). The field of expert-novice research explores "the characteristics, skills, and knowledge that distinguish experts from novices and less experienced people" (Ericsson, 2006, p. 3). To measure these facets of expertise, Ericsson and colleagues highlight experts' behavior that is reproducible and superior to their Non-expert and Novice counterparts. In the domain of sports, these expert behaviors, such as highly aggressive forehands in tennis, are clearly visible and attract the devotion of millions of fans. Many emerging athletes and recreational players, however, wish to learn how to emulate the practices of these experts, and it is within this area of study that more focused research is needed.

Automaticity and its Role in Skill Development

Automaticity has been defined as the point at which execution of a skill can be performed without deliberate attention (Feltovich, Prietula, & Ericson, 2006). Fitts and Posner (1967) hypothesized that automaticity emerges in three progressive stages. An initial *cognitive* *associative* stage focuses on the mental representations of a skill. At this stage, a learner's attention to skill processes consumes working memory. In the second stage, a skill is performed with the continuous guidance and feedback of a teacher, which gradually reduces the cognitive load. Finally, at a third and final stage, the learner can perform the skill automatically without the need for conscious control.

One view of the effects of automaticity is that it enhances athletic performance. For example, Singer and his colleagues (Singer, 1988; Singer & Cauragh, 1985; Singer, Lidor & Cauragh, 1993, Singer, Lidor & Cauragh, 1994) reported evidence of superior skill performance in the absence of conscious control. Based on their research, they recommended practicing and playing sports with a "quiet mind" (Singer, Lidor & Cauraugh, 1993, p. 22). By watching a skilled performer complete a skill, observers develop a mental representation through the use of cognitive regulators, such as visual imagery. The skill is then performed without attention to behavioral processes or outcomes. Attention is instead focused on a point or object in space, such as the brand name printed on the tennis ball. Singer and colleagues warn that, by focusing attention on execution during practice or play, the quality of a skill's execution is diminished. Thus, the goal of the learner should be to achieve automaticity through the avoidance of attention to performance processes.

In addition to Singer and his colleagues, other researchers have reported diminished athletic performance when automaticity is impaired. According to these researchers (Beilock, Carr, MacMahon, & Starkes, 2002; Hodges, Starkes, MacMahon, 2006; Kimble & Perlmuter, 1970, McPherson & French, 1991, McPherson, 2000), automaticity involves more efficient processing of information. Novices initially need to focus on the declarative units or structures that make up the overall skill, such as the part of the foot that makes contact with a soccer ball during dribbling. With practice, athletes use rules to chunk procedures into "efficient productions" (Hodges, Starkes, MacMahon, 2006, p. 479). According to this view, attention is no longer required to execute sub-skills correctly, and the fluidity of combined execution is disrupted by this deliberate focusing of attention. As Beilock and colleagues (2002) explained, "Once broken down, each unit must be activated and run separately, which slows performance and, at each transition between units, creates an opportunity for error that was not present in the "chunked" control structure" (Beilock et. al, 2002, p. 8). This body of literature therefore supports the importance of automaticity for enhanced performance.

By contrast to these positive perspectives on the role of automaticity in athletic performance, Ericsson and his colleagues (1993) contend that automaticity can impair the development in athletic expertise because it reduces cognitive attention and conscious control. Ericsson et al. suggest that this state of arrested development can be prevented by *deliberate practice*, during which the learner focuses assiduously on mastering specific processes that have been emphasized by experts. According to Ericsson, the highest priority for "aspiring expert performers is to avoid the arrested development associated with automaticity and to acquire cognitive skills to support their continued learning and improvement" (2006, p. 694). The effectiveness of a process goal state is demonstrated empirically in Ericsson and his colleagues' research (Feltovich, Prietula, & Ericson, 2006).

A third perspective on automaticity emphasizes its dynamic properties. Zimmerman and his colleagues (Kitsantas & Zimmerman, 1997, Zimmerman, 2002) contend that Singer's and Ericsson's views are both valid, but they deal with two different issues. Singer and colleagues focused on the positive impact of automaticity on athletic *performance* whereas Ericsson and colleagues focused on the negative impact of automaticity on the *acquisition* of expertise (i.e., *learning*). Zimmerman et al. hypothesized expert self-regulators must be able to shift adaptively between a process and an outcome focus. Like Ericsson and his colleagues, Zimmerman et al. hypothesize that the act of slowing down one's performance in order to attend to and regulate sub-processes separately is necessary to continue to improve learning (Ericsson, 2006; Zimmerman, 2007). In this way, an expert self-regulator can optimize cognitive attention on specific aspects of complex procedures in order to improve their acquisition. Ericsson (2006) contends that learning is enhanced when a learner deliberately slows down his or her performance in order to coordinate athletic sub-processes more effectively. However, like Singer, Starkes, and their colleagues, Zimmerman and colleagues contend that automaticity is advantageous once a high level of learning has taken place. However, they hypothesize that experts self-regulate optimally by shifting their attention from adverse performance outcomes to learning processes.

There is much anecdotal evidence that skill automaticity is not a static state of attainment. Professional athletes practice shot making techniques (i.e., learning processes) for hours each day, yet their performance from tournament to tournament often fluctuates greatly. Positive and negative performance outcomes of an automatized performance can lead to a shift in a learner's focus to processes. For example, professional tennis players are keenly aware of the possibility of an error or breakdown in a skill can occur at any time and the need to shift to a process focus during both matches and subsequent practice sessions when one's level of skill is lacking. In order to meet either self-imposed or competitively imposed challenges, an automatized state would seem insufficient to ensure peak performance. As a case in point, the golf pro Tiger Woods decided he needed to dissect his drive in order to focus on the process minutia that would produce greater yardage and accuracy. During this period of development, Woods shifted his attention away from outcomes (i.e., winning) to bring the full force of his attention onto the processes involved in his drive.

Goal Setting and Automaticity

Improving one's level of expertise and maintaining a high level of performance require the adaptive use of goals (Zimmerman, 2008). Goals are often linked to the construction of plans to achieve desired outcomes and can be targeted at either the process level, which entails the development of a skill, or the outcome level, which is signified by the effectiveness of a skill. Goals are also associated with such motivational outcomes as task attention, increased effort, and sustained persistence (Locke & Latham, 1990; Kitzantas & Zimmerman, 2002; Harwood, Cumming, & Fletcher, 2003; Zimmerman, 2008). Zimmerman (2008) commented that "goals motivate students' choice of and attention to goal-relevant tasks" (p. 268). Only in bringing specific components of performance to one's attention can one reflect upon and hope to improve them.

Zimmerman and Kitsantas (1997, 1999) found empirical support for a shifting goal approach to motoric and academic skill development. In the motoric skill study (1997), a process goal group, an outcome goal group, and a shifting goal group attempted a dart-throwing challenge. In order to maximize skill development, participants in the shifting goal group were instructed to shift from process to outcome goals at the point of automaticity. Participants in this shifting goal group practiced a dart-throwing skill for a pre-determined amount of time, and were then informed that they should shift to outcome goals. This group executed the dart skill to a higher standard of target accuracy than the process or outcome only groups. Participants in the outcome goal group performed the skill less accurately than the other groups.

The act of teaching novices to maintain a process goal state for an *extended* amount of time should maximize the opportunity to emulate the practices of experts. Novices regularly fail to adequately self-evaluate, which can lead to miscalibrating judgments of competence (Stipek & Tannatt, 1985, Newman & Wick, 1987). This miscalibration tends to be heavily skewed toward an overestimation of ability, or what Newman and Wick call a "bias toward optimism" among children, which prevents them from dedicating the time and attention necessary to more completely learn a skill. Experts, on the other hand, self-evaluate in comparison to a desired level of performance, allowing them to accurately calibrate their judgments of competence with actual progress and to make the necessary adaptations to continually approximate the desired behavior (Kitsantas & Zimmerman, 2002). These types of findings have been discovered across domains. In the field of academics, for example, Gettinger (1985) focused on academic study time spent trying to achieve a top score in a quiz. The experimental group that was allowed to self-regulate time on task spent sixty-eight percent of the time predicted to be required by the researchers which in turn adversely affected performance.

The use of process-related verbalizations has been successfully used to maintain participants' focus of attention on mental representations of key processes (Beilock, Carr, MacMahon, & Starkes, 2002). This verbalization aid was referred to as *skills focusing*. In an expert-novice comparative study, soccer players learned to dribble a ball through a slalom course of cones. The authors found that novices benefited from this process verbalization link, allowing them to maintain focus on the mental representation of these processes, enhancing skill development as a result. They also found that experts suffered from verbalizing the sub-processes or techniques involved in the soccer drill, which was attributed to the disruption of their proceduralized skill.

Proposed Study

The proposed study seeks to provide further evidence supporting a dynamic view of automaticity and athletic expertise. Zimmerman and his colleagues have demonstrated that a shift in goal setting during the course of learning produced superior performance compared to static process or outcome goals. Students were instructed when to shift based on the experimenters' criterion of automatized performance (i.e., 12 minutes of practicing process steps). Many questions remain regarding the role of deliberate practice and automaticity, such as when a learner should shift from process goals to outcome goals? Should they shift as soon as possible or should they shift after extensive deliberate practice? If students can choose for themselves regarding when to shift, do they learn a motoric skill more effectively, and at what point during practice do they make the shift? Answers to these questions would greatly enhance our understanding of when and how learners can self-regulate by altering their learning and performance goals.

This dissertation explores the issue of automaticity during novice tennis players' acquisition of skill. More specifically, the benefits of providing an environment for learners to minimize the problems associated with novice practice, while maximizing the benefits associated with expert self-regulatory practice were investigated. Zimmerman and colleague's shifting goal design was modified to expand our understanding of expert self-regulatory practice methods. Two experimental groups had the point of shifting experimentally controlled so that one of the groups shifted to outcome goals following an extended number of process attempts (*Extended Process Group*), while the other group shifted after an intermediate number of process attempts relative to other groups (*Intermediate Process Group*). A third experimental group of novices were permitted to self-shift to outcome goals at the point when participants decided the sub-processes of the tennis stroke were sufficiently developed (*Self Shifting Group*). This was designed to further explore the research stipulating how, when left to their own devices, novices are prone to inaccurately estimate their level of skill, often over-anticipating positive outcomes (Stipek & Tannatt, 1985; Newman & Wick, 1987). An *Outcome Goal Group*, spending the entire study focusing on outcome goals, acted as a control. This experimental design shed light on the degree of practice necessary to make significant refinements to the development of a skill, similar to the manner in which proactive learners or experts practice.

CHAPTER TWO

LITERATURE REVIEW

The purpose of this chapter is fourfold: 1) to review research on the construct of automaticity as it relates to athletic performance, 2) to present a social cognitive analysis of automaticity and empirical support for its use in this dissertation, 3) to outline expert practice methods that were examined while teaching novices a tennis stroke, and empirical support for their examination and, 4) to demonstrate empirically a justification for the microanalytic methodology that was used in this research. Hypotheses supported by a review of the literature will follow these sections.

The Construct of Automaticity as it Relates to Athletic Performance

Automaticity is that rare topic where compelling research can be found to support seemingly conflicting perspectives in studies examining expert athletic performance. One perspective discourages focusing attention on athletic processes, and supports automaticity as the ultimate goal of athletes. In contrast to this *process avoidance* perspective, a *process focus* view encourages attention to processes, portraying automaticity as antithetical to acquisition of athletic skill. A third dynamic view of automaticity emphasizes instead a shift in attention from learning processes to performance outcomes guided by metacognitive goal setting. Thus, automaticity can be both helpful and harmful depending on its alignment with one's goals. This section will review these different findings, demonstrating an alignment with a social cognitive perspective.

Research on a Process Avoidance Perspective

Singer and his colleagues (Singer, 1988; Singer & Cauragh, 1985; Singer, Lidor & Cauragh, 1993; Singer, Lidor & Cauragh, 1994) advocate a negative perspective on attention to processes during the performance of a skill. Singer et al. (1993) state that “attaining a state of automaticity in routine acts is the goal in any mastery situation” (p. 21). Regarding the skill of tennis, Loehr (1982) similarly claims that the best tennis players “seem to know what to do without thinking about it” (p. 21). This “mental zone” perspective does not distinguish among contexts in which experts perform, such as practice versus competitive performance. Singer et al. (p. 20) emphasize “letting go” as the path to achieving automatized level of athletic functioning.

However, operationally defining “letting go” represents a challenge to experimentation. How can we assess whether an athlete is in a state of “letting go?” Singer and colleagues (1988; Singer, Lidor & Cauraugh, 1993; Singer, Lidor & Cauraugh, 1994) advocated a five step approach for achieving “letting go” and tested the validity of their theory by teaching a beginner a throwing action at an arbitrary target using their non-dominant hand. The five step approach was summarized as “learning to prepare for an act, to image, to focus on a meaningful cue, to execute with a quiet mind, and to evaluate (if time permits)” (p. 21). For the *five step* group, a mental representation was gradually developed by hearing a general description of the throwing processes and objective. In this approach, attention to processes occurred in the absence of overt behavior. During execution, participants were instructed to focus attention on the target area, but to pay no attention to movement cues. Participants were then described as performing the throwing skill without attention to processes, performing the skill instead with a “quiet mind” (p. 22).

Another experimental group, known as the *awareness* group, was instead instructed to focus on their current process ability during execution. This was operationally defined as instructing the group to be aware of how they throw the ball, how the movement feels, and what sound the ball makes as it hits the target. This group was not instructed to look at the center of the target as with the *five step* group, nor were they taught a correct throwing technique.

The five step group performed significantly better at hitting close to the target more frequently overall than the awareness group. Singer and colleagues' (Singer, DeFrancesco, & Randall, 1989; Singer, Flora, & Abourezk, 1989; Singer & Suwanthada, 1986) replicated these findings in other research, which led them to conclude that it was possible to teach beginners expert practice habits.

However, this conclusion may have been premature. In these studies, the *awareness* group was not taught awareness of processes that underlie the correct throwing action, such as windup, aiming, and release. Instead, the group was guided to be aware of their beginner throwing action and how it felt. It seems unlikely that focusing on potentially incorrect processes could have led to improved performance. Zimmerman and Kitsantas (1997, 1999), for example, demonstrated differences among groups that resulted from explicit process instruction and practice (explained in depth in a later section). In addition, Singer et al. (1993) acknowledged that the *five step* group required substantially more time to complete the steps than the awareness group. This time differential poses a threat to the internal test validity of the design. It is unknown whether, in fact, the difference in time spent on task led to group differences.

The *five step* group's attention to a description of the throwing action sub-processes constitutes a form of vicarious learning that has been demonstrated in social cognitive research to enhance learning (Bandura, 1986; Zimmerman, 2002). Without an examination of the unique contribution of this element of the group's procedure, it is difficult to know if a five step model was required at all, or whether in fact this demonstrates the demonstrated benefits of vicarious learning.

Finally, there was a difference between the groups in relation to outcome goals. The *five step* group focused visually on the target during actual execution, representing a shift in attention to outcomes during performance. In contrast, the *awareness* group focused attention on the sound of the ball as it hit the target. The sound associated with hitting the target was unlikely to enhance a visual focus on the actual target itself, and represents a potential confound to the findings of the study. In fact, the procedure for the *awareness* group did not require looking at the target at all. Overall, there would appear to be inaccuracies in Singer's inferences regarding the negative outcomes of attention to processes based on the operational definitions used in the research.

Another body of research found support for a process avoidance perspective on athletic skill development (Beilock, Carr, MacMahon, & Starkes, 2002; Hodges, Starkes, MacMahon, 2006; Kimble & Perlmuter, 1970, McPherson & French, 1991, McPherson, 2000). These researchers take an information processing perspective of skill acquisition, claiming that compilations of rules form larger chunked procedures or "efficient productions" that are superior to other modes of performance (Hodges, Starkes, MacMahon, 2006, p. 479). Automaticity is viewed as higher cognitive regulation of lower level motoric processes.

These researchers defined automaticity as the execution of a skill without the need for verbalizable knowledge to be brought into working memory (Beilock et al., 2002). In this way, automaticity is defined negatively in that this definition emphasizes what *not* to focus on. Performance with a concurrent verbal performance-specific description is posited to disrupt automaticity. The position held is that, as attention is no longer required to execute sub-skills correctly, the fluidity of combined execution is disrupted by this deliberate attentional focusing. As Beilock and colleagues explain, "Once broken down, each unit must be activated and run separately, which slows performance and, at each transition between units, creates an opportunity for error that was not present in the "chunked" control structure" (p. 8). Performance, therefore, is enhanced by its efficient production according to this research.

Beilock et al. (2002) studied skilled soccer players' performance on a ball dribbling task. Using their dominant foot, a *dual-task* group engaged in an auditory word-monitoring task while performing the dribbling task. A *skills focusing* group focused instead on the side of the foot that made contact with the ball. The dribbling speed around the course was found to be faster for the *dual task* group, and in addition, the *skills focusing* group was claimed to suffer from verbalizing the sub-processes involved in the soccer drill. This was attributed to the disruption of experts' efficient production

The outcome measured in this research was speed around the dribbling course. Because the *skills focusing* group performed slower than the *dual-task* group, it was inferred that performance is slowed down by focusing on processes, that this creates an opportunity for error and, that these outcomes have an overall negative effect on performance. It is difficult to dispute that speed is an important component of most sports, including soccer and tennis, but the results could also prompt the question: What would the participants have done in order to improve their personal best time? If they repeated the drill while avoiding a focus on 'how' speed is being generated, it seems unlikely they would increase their speed substantially.

The coordination of ball control at speed necessitates multiple sequential actions and shifts in center of gravity. Ericsson (2006) has demonstrated that repeated experience alone is insufficient in explaining expert performance. One need only observe any professional tennis player to know that, despite the remarkably efficient production of skills, numerous errors occur nonetheless. An athlete's skill level is not static, and in fact, it can deteriorate at *any* time, for myriad reasons. Professional tennis players practice skills for hours each day, yet their performance from tournament to tournament fluctuates greatly. Upon executing an automatized skill, which, according to Beilock and colleagues is routinized sufficiently to be performed while answering word problems, one might expect the level of reward experienced to be negligible. Contrary to this assumption, tennis players regularly appear exalted when they hit a winning shot. They do this despite spending hundreds or even thousands of hours practicing the same type of shot successfully in practice. It seems more likely that players are keenly aware of the possibility of error or breakdown in a skill from time to time.

There is tremendous pressure on athletes to improve their skills to meet either self-imposed or competitively imposed challenges. Unforced errors represent an important statistic for a tennis player to monitor because no player can play well and win consistently with a high proportion of unforced errors. In the 2008 Australian Open semi-final, for example, the world number 14 player, Fernando Verdasco, hit 95 winners, twice as many as the average 5 set match produces, yet he still lost to the world number 1 player, Rafael Nadal (Australian Open, 2009a). The key statistic was Verdasco's 76 unforced errors in comparison to Nadal's 25 unforced errors and 52 winners. Verdasco's margin for error was simply too marginal for victory.

If athletes followed Beilock and colleagues' model of procedural knowledge dependency, they would not be capable of deliberately altering their skill level. This season, Verdasco must hit a higher proportion of winners to unforced errors if he is to beat Nadal. How will he do that if he continues with the same stroke characteristics? Extending transitions between sub-units of a stroke during practice may, as Beilock and colleagues claim, create opportunity for error, but it will also create an opportunity for success. Tennis legend Roger Federer also succumbed to Nadal in the 2008 Australian Open, in part due to his inability to capitalize on his excellent forehand return of second serves. Federer only made two returns of Nadal's second serve off his forehand side, both of which he won. Otherwise, Federer stuck to his conventional backhand procedure in response to Nadal's serve to the backhand side. Davis Cup coach Pat McEnroe pointed out that this procedural error may have made the difference in the match. Their match statistics show that the only real difference between the two players was on break point conversions, with Nadal winning 44 percent in comparison to Federer's 32 percent (Australian Open, 2009b). Overall, researchers who recommend remaining in a state of automaticity do not provide a comprehensive description of optimal performance.

Research on a Process Focus Perspective

An alternative view of automaticity was advanced by Ericsson (2003) in his theory of deliberate practice (2003). He suggested that deliberate practice occurs "when a person engages in a practice activity (typically designed by teachers) with the primary goal of improving some aspect of performance" (p. 67). This attention to processes is posited by Ericsson to prevent the arrested development associated with automaticity. According to Ericsson, automaticity can be defined as a state in which performance occurs with reduced conscious attention and cognitive control. But unlike proponents who see automaticity as advantageous, Ericsson contends that reduced attentional control leads to diminished athletic development. He cautions, "As a consequence of automatization, performers lose the ability to control the execution of those skills, making intentional modifications and adjustments difficult" (Ericsson, 2006, pp. 684-685).

For example, Ericsson, Krampe, and Tesch-Romer (1993) reviewed writing logs of expert violinists at the music academy in Berlin, and he found measurable differences in skill despite having spent equal time on domain-specific activities. Skill at playing the violin positively correlated with time spent on teacher-directed, process focused tasks, rather than simple repetition or accumulated hours of practice. According to Ericsson, the highest priority for "aspiring expert performers is to avoid the arrested development associated with automaticity and to acquire cognitive skills to support their continued learning and improvement" (2006, p. 694). In these ways, attention to processes and the avoidance of 'mindless' automaticity are imperative to the development of expertise, according to Ericsson.

Differences in the rankings of chess players (Charness, Krampe, & Mayr, 1996) and tennis players (Schneider, 1997) have been attributed to differences in deliberate practice. In each study, a ranking number was established as an outcome measure for each player. Tournament performance and deliberate practice were then used to predict the outcome measure. By statistically controlling deliberate practice, the researchers found that tournament performance contributed little to differences among players. In the tennis study, for example, Schneider (1997) studied 5 years of data on the measures mentioned above in relation to a sample of top-ranked teenage tennis players. The majority of explained variance in ranking at the end of the five year period was predicted by the amount and intensity of deliberate practice.

Research on a Process/Outcome Focus

Beilock and his colleagues' view of automaticity as an end point in skill acquisition face validity challenges. As previously outlined, an anecdotal analysis of the recent Australian Open reveals the necessity for even world class players to shift the focus of their attention from automaticity to deliberate practice or risk defeat. Similarly, the superiority of a process focus, and the avoidance of automaticity at all costs in Ericsson's model of deliberate practice, must also face further scrutiny. A more empirical validation and operational definition of this viewpoint is outlined below.

Competitive situations provide a severe test of one's skills, and performance outcomes preoccupy the attention of competitors as they attempt to win. As Zimmerman and Kitsantas (1997) explain, "by definition, outcome goals provide the ultimate criterion by which process attainments can be measured" (p. 30). It follows, therefore, that the outcomes related to a skill should be tested at the point when the processes can be performed to a high enough standard to justify attention to outcomes. From a social cognitive perspective such as that presented by Zimmerman, automaticity is a consequence of adaptive goal setting, specifically resulting from a deliberate focus on outcome goals. Automaticity is viewed as "the shift from intentional to automatic processing that is controlled by metacognitive goal setting, which focus on either learning processes (requiring constant attention) or performance outcomes (triggering automaticity)" (Zimmerman, 2009, personal communication). A model that explains the development of this shifting ability through metacognitive goal setting was described by Zimmerman (2002). This model outlines four developmental levels that culminate in the adaptive use of skills that are self-regulated by ongoing performance-related sources of information. These levels: 1) Observation, 2) Emulation, 3) Self-control, and 4) Self-regulation are explained and verified with empirical support below. *Table 1* illustrates the progressive sequence of goals and action that culminate in a self-regulatory level of competence.

Table 1.
Social and Self-Sources of Regulation

	Features of Regulations			
Levels of Regul	*Sources of Regulation*	*Sources of Moti*	*Task Condition*	*Performance Ind*
Observation	Modeling	Vicarious reinforcement	Presence of mc	Discrimination
Emulation	Performance & social feedback	Direct/social reinforcement	Correspond to models	Stylistic duplicat
Self-control	Representation of proc standards	Self-reinforceme self-incentive	Structured	Automatization
Self-regulation	Performance/outcomes	Self-efficacy bel	Dynamic	Adaptation

From Zimmerman, B. (2002). "Achieving self-regulation: The trial and triumph of adolescence." In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (vol. 2, pp 1-27). Greenwich, CT: Information Age.

Observation. This level of skill occurs when learners can discriminate major features of the skill or strategy from watching a model learn or perform. This usually requires repeated observations, while the underlying motivation to learn can be enhanced by observing positive vicarious outcomes of a model's behavior. That is, a learner need not undertake the physical activity to learn cognitively at this stage.

Emulation. This level of self-regulatory skill is attained when the learner's performance approximates the general structure of that of the model. Motivation to perform is provided, in part, by the guidance of feedback along the way. Kitsantas, Zimmerman, and Cleary (2000) demonstrated the acquisition of a dart throwing skill using observation and emulation. During observation, viewing coping models was found to provide an optimal model of self-regulatory skill development due to the necessity for this group to monitor and evaluate errors. During emulation, girls who received social feedback learned better than those who practiced in the absence of feedback. This was only the case, however, for the girls who viewed models, indicating the sequential development of self-regulatory competence.

Self-control. A self-controlled level of self-regulatory skill development occurs when learners practice the use of the skill in structured settings in the absence of social models. Practice involves the use of mental representations and self-reinforcement (for meeting a standard). As a high level self-control is achieved, automaticity emerges.

Self-regulation. A self-regulated level of performance is achieved when learners can systematically adapt their performance differing contexts. Learners adjust their processes based on the information provided by outcomes, therefore necessitating self-monitoring rather than observing a model. Zimmerman and Kitsantas (1997) studied learners' ability to shift goals from processes to outcomes at the point of automatized dart throwing. Participants who focused on processes during a self-control phase were more successful at achieving automaticity in comparison to an outcome goal group. Shifting at this point to an outcome focus was tested against groups who focused on process only or outcome only goals. Highest skill development was achieved by the shifting goal group.

Expert Self-Regulatory Practice Methods

The ability to teach novices to learn expert self-regulatory practice methods should be an important goal for instructors and teachers in all pursuits. Practice methods that were tested in this dissertation, the first of which (metacognitive shifting goals) was introduced in the previous section, are outlined in detail below.

Metacognitive shifting goals. Following social cognitive research by Zimmerman and colleagues (Kitsantas & Zimmerman, 1997; Zimmerman, 2002), the position taken here is that both a process and an outcome focus must be capable of being manipulated by the expert self-regulator. Zimmerman and Kitsantas (1997, 1999) found empirical support for a shifting goal approach to motoric and academic skill development. In the motoric skill study (1997), a process goal group, an outcome goal group, and a shifting goal group attempted a dart-throwing challenge. In order to maximize skill development, participants in the shifting goal group were instructed to shift from process to outcome goals at the point of automaticity. Participants in this shifting goal group practiced a dart-throwing skill for a pre-determined amount of time, and were then informed that they should shift to outcome goals. This group executed the dart skill to a higher standard than the process or outcome only groups. Participants in the outcome goal group performed the skill to a significantly lower standard than the other groups.

Strategy attributions. Expert performance necessitates a level of metacognitive control over the use of automatized skills. In this way, expert practice also requires recognition of when outcome goals are not sufficient for continued enhancement of performance. In a recent study of volleyball players' practice of the serve, Kitsantas and Zimmerman (2002) described how experts were consistently superior at attributing failed performance to strategic processes, thereby allowing them to control and alter processes with the goal of improving their serving skill. In previous research (Zimmerman & Kitsantas, 1999), the authors had found that attributing failure to strategy rather than ability or effort could be highly motivating and lead to more successful adaptations when attempting to learn from failure. Failure is clearly a common occurrence in skill development, but with the right form of instruction, novices could also develop controllable attributions.

Novices tend to suffer both immediately and cyclically from making uncontrollable attributions (Kitsantas & Zimmerman, 2002). They are prone to attribute failed attempts to ability, even when they feel they were incapable of exerting more effort. They can then become prone to defensiveness, avoidance of challenge, and disengagement, thereby reinforcing the negative opinion of their effortful capacity or ability (Schunk, 2008). This can have a negative effect, both on the development of expertise, and on the motivation of novices, as they become less likely to express interest in a task that is experienced as being too difficult. Task interest acts as an important motive in maintaining self-regulatory cycles of forethought, performance control, and self-evaluation (Zimmerman, 2008).

Extended processes. The act of teaching novices to maintain a process goal state for an extended amount of time should maximize the opportunity to emulate the practices of experts. The act of slowing down performance to attend to sub-processes separately is necessary to continue to improve performance (Zimmerman, 2007; Ericsson, 2006). In this way, an expert self-regulator can maintain cognitive attention on specific aspects of complex procedures in order to modify execution (Ericsson, 2006). Therefore, it is the precise act of deliberately slowing down performance in order to run sub-processes separately that allows expert deliberate practice to occur. Tennis procedures, even at the rudimentary level, involve multiple dynamic sequences of coordinated movement. This is due to the reactive timing of tennis strokes to the oncoming ball. Experts and novices alike must spend significant time practicing sub-processes in order to be confident of performing at an automatized level.

Novices regularly fail to accurately self-evaluate, which can lead to miscalibrating judgments of competence (Stipek &_Tannatt, 1985; Newman & Wick, 1987). This miscalibration tends to be heavily skewed toward an overestimation of ability, or what Newman and Wick call a "bias toward optimism" among children, which can prevent them from dedicating the time and attention necessary to more completely learn a skill. Experts, on the other hand, self-evaluate in comparison to a desired level of performance, allowing them to accurately calibrate their judgments of competence with actual progress, and make the necessary adaptations to approximate the desired behavior (Kitsantas & Zimmerman, 2002). These types of findings have been discovered across domains. In the field of academics, for example, Gettinger (1985) focused on academic study time that was spent trying to achieve a top score in a quiz. An experimental group that allowed students to self-regulate time on task spent sixty-eight percent of the time that was needed and this adversely affected their performance.

Self-efficacy. The development of expertise requires confidence in one's ability to continually improve. Self-efficacy refers to the belief in one's capabilities to perform at designated levels (Schunk, 2008). If a novice player believes a skill is beyond his or her control or ability, it is highly unlikely that the necessary persistence required to make improvements will be demonstrated. These self-motivational capabilities are important in aiding forethought (Zimmerman, 2008). According to Zimmerman, proactive learners are said to utilize these motivations for the purpose of self-improvement. Within this social cognitive model of self-regulation, these self-motivations are also affected by learning and performance.

Goal orientations. Goal orientations are both "precursors" to and "outcomes" of performance (Zimmerman, 2008, p. 7). A performance or outcome orientation relates to gaining or avoiding judgments regarding competence, whereas a mastery or process orientation is related to the development of competence itself (Elliot & McGregor, 2001). Goal orientation theorists view these traits largely as stable over time. By contrast, social-cognitive theorists such as Bandura, Zimmerman, and Schunk view the learner's orientation to a task as fluid, adjusting to the demands of the environment across different situations and phases. Within sport psychology, there is growing research that athletes tend to be both performance *and* mastery oriented

(Cumming, Hall, Harwood, & Gammage, 2002; Harwood, Cumming, & Fletcher, 2003). This combination of orientations has been explained as follows, “performers reporting a *complementary balance* of both the desire to demonstrate superior abilities over others and to progress and develop through personal mastery are more motivated to engage in tasks that maximize achievement” (Harwood, Cumming, & Fletcher, 2003, p. 320, italics added). This research has yet to provide clarity as to how and when different goal orientations are activated in relation to the myriad challenges facing athletes, such as practice versus tournament situations. Harwood and Swain cautioned that “few interventions have actually targeted changes in achievement goal orientations or goal involvement responses as specific dependent variables” (2002, p. 112). By manipulating both the type and duration of players’ goal states, this dissertation shed light on the dynamic relation between learning processes and performance outcomes.

A Microanalytic Method of Analysis

The data gathering process selected for this dissertation is known as microanalysis (Bandura, 1997; Cleary & Zimmerman, 2001, 2004; Zimmerman & Kitsantas, 2002). Short, theory-informed questions are asked during the execution of specific behaviors of interest. Questions are designed to address well-established psychological processes, such as goal setting, attributions, and self-efficacy. This level of specificity in exploring cognitive processes was also recommended in expert-novice research. Ericsson claims “Studies of the microstructure of deliberate practice would be a much better context for collecting the athletes’ thoughts and immediate judgments of concentration” (2003, p. 392). Due to the online nature of micro-analysis, data is collected on subjects individually, so that contextualized responses are recorded accurately, maximizing the likelihood of delivering the most accurate answer to pointed questions.

Examining attributions of causation, for example, is an important component of a microanalytic methodology. The clarity and timing of questions regarding this motivational process are imperative to valid inferences regarding interventions. “This type of ‘online’ assessment approach differs from most retrospective procedures because it assesses students’ specific mental and behavioral processes as they occur and change” (Cleary & Zimmerman, 2004, p. 540). In this way, re-interpretations that occur during post-performance self-report questionnaires can be studied.

This chapter has presented research investigating the issue of automaticity in athletic performance. Research by Singer, Beilock and colleagues attests to the benefits of avoiding attention to performance processes whereas Ericsson’s research attests to the benefits of deliberate attention to learning processes. Social cognitive research by Zimmerman and colleagues was outlined, demonstrating a dynamic stance on the subject of automaticity in which goals and environmental feedback interact to create the need to shift attention between performance processes and performance outcomes. This dissertation planned to help clarify issues surrounding automaticity, in particular as they relate to novice tennis skill acquisition. An additional aim was to demonstrate the benefits of providing an environment for learners to minimize the problems associated with novice practice, while maximizing the benefits of practice associated with expertise.

The shifting goal design was modified to expand our understanding of expert self-regulatory practice methods. Two experimental groups had the point of shifting experimentally controlled so that one of the groups (*Extended Process Group*) shifted to outcome goals following an extended number of process attempts, while the other group (*Intermediate Process Group*) shifted after an intermediate number of process attempts relative to other groups. A third experimental group of novices (*Self-Shifting Group*) were permitted to self-shift to outcome goals at the point when participants decided the sub-processes of the tennis stroke were sufficiently developed. This was designed to further explore the research stipulating how, when left to their own devices, novices are prone to inaccurately estimate their level of skill, often over-anticipating positive outcomes (Stipek & Tannatt, 1985; Newman & Wick, 1987). An *Outcome Goal Group*, spending the entire study focusing on outcome goals, acted as a control. This experimental design aimed at shedding light on the degree of practice necessary to make significant refinements to the development of a skill, similar to the manner in which proactive learners or experts practice. Gauging both learning and performance differences are important contributions of this research.

In this dissertation, the issue of remaining in a process state, an outcome focus, or a dynamic state progressing from processes to outcomes following extended practice was explored using this four group design. The ability to adapt goals to contextual events and make performance enhancing attributions was also examined. Taken together, this dissertation examines significant elements of expert practice and the degree to which novice tennis players can benefit from them.

Hypotheses: Behavioral Measures

1. The level of target accuracy (based on shots landing in the target area) is predicted to be highest for the *Extended Process Group*, next highest for the *Intermediate Process Group*, followed by the *Self-Shifting Group*, and was predicted to be lowest for the *Outcome Goal Group*. These differences are not predicted to emerge until Practice Phase Three, that is, until

the 41st to 60th attempts. No differences are predicted following Practice Phase One (attempts 1 to 20) or Practice Phase Two (attempts 21 to 40).

2. A significant practice phase effect is predicted for target accuracy.

3. No gender or age differences are predicted for any measures.

4. Groups in a process goal condition are predicted to score higher on the measure of foot and racquet placement during practice phase three than the *Outcome Goal Group* (control). Among groups in a process goal condition, the *Extended Process Group* is predicted to score highest, followed by the *Intermediate Process Group*, and finally the *Self-Shifting Group*. These differences were not predicted to emerge until Practice Phase Three, that is, no differences are predicted following Practice Phase One (attempts 1 to 20) or Practice Phase Two (attempts 21 to 40).

5. A significant practice phase effect is predicted for foot and racquet placement.

6. Groups in a process goal condition are predicted to score higher on the measure of hitting the sweet spot during practice phase three than the *Outcome Goal Group* (control). Among groups in a process goal condition, the *Extended Process Group* is predicted to score highest, followed by the *Intermediate Process Group*, and finally the *Self-Shifting Group*. These differences are not predicted to emerge until Practice Phase Three, that is, no differences are predicted following Practice Phase One (attempts 1 to 20) or Practice Phase Two (attempts 21 to 40).

7. A significant practice phase effect is predicted for hitting the sweet spot.

Hypotheses: Self-Regulation

1. Groups with a process focus are predicted to set significantly more process goals overall, with the *Extended Process Group* predicted to set the most process goals, followed by the

Intermediate Process Group, then the *Self-Shifting Group*, and finally the *Outcome Goal Group*. This may seem intuitive, but goal orientation theorists propose a more dispositional goal paradigm, meaning that the goals that learners set are largely stable over time (Elliot & McGregor, 2001). For this reason, self-report questionnaires are often lengthy and administered after performance, implicitly suggesting that the player's sense of their goal orientation will not change between performance and post-performance, will not change between phases of learning, and that their memory of past events will be objective and clear.

2. The point of shifting from process to outcome goals for the *Self-Shifting Group* is predicted to be sooner than the other experimental groups.
3. Self-efficacy is predicted to be highest for the *Extended Process Group*, next highest for the *Intermediate Process Group*, followed by the *Self-Shifting Group*, and finally the *Outcome Goal Group*.
4. Groups receiving a process practice session are predicted to make significantly more strategy attributions than the *Outcome Goal Group*, while the *Extended Process Group* is expected to make highest number of strategy attributions, next highest is predicted to be the *Intermediate Process Group*, followed by the *Self-Shifting Group*, and finally the *Outcome Goal Group*.

CHAPTER THREE

METHODOLOGY AND PROCEDURES

Participants

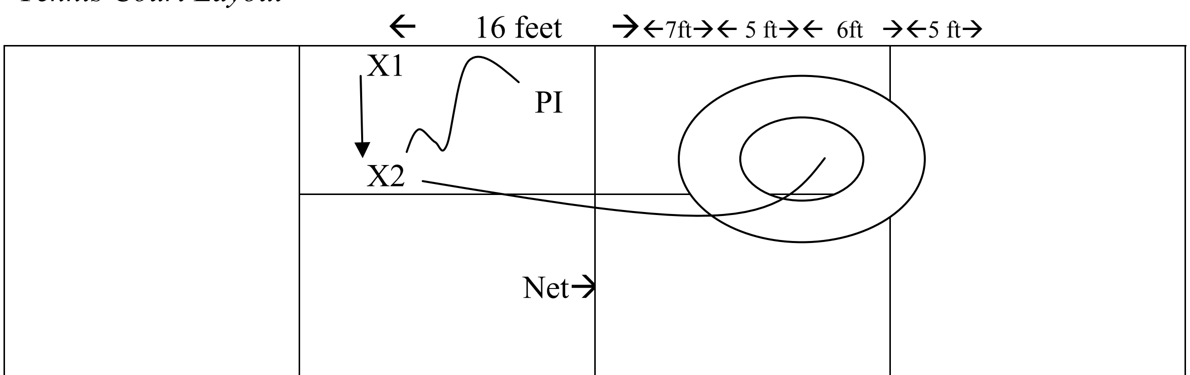
Participants were middle school students in 6^{th} and 7^{th} grade attending a public school in the Northeast. Forty six students took part in the study, of which forty qualified as novices. Participants qualified as novices if they scored less than fourteen points out of a possible eighty points during their initial twenty practice attempts. This novice – non-novice differentiation was decided upon based on pilot work for this study, during which volunteers with no tennis experience consistently scored less than fourteen points in the same trials. All participants received a medal for engaging in this study. The statistical power for this sample to detect a medium size effect is 76% at $p > .05$ and a large size effect is 99% at $p < .05$ (Cohen, 1988). Strong statistical effects have been reported in prior research (Zimmerman & Kitsantas, 1997; 1999).

Task Materials

Participants utilized a process skill focusing teaching aid to maintain process-focused groups' attention to the tennis stroke they are attempting to learn. Novices played with a tennis racquet adapted to make a clearly distinguishable sound at the point of contact should they hit the ball off the optimal part of the strings for correct stroke production. This is called the 'sweet spot'. A sweet spot refers to the middle part of the string formation that allows the least vibration, and maximum velocity of a stroke per unit of expended effort. An expert can feel and hear the striking of a ball against the sweet spot, but a novice is unlikely to have developed this capacity. Therefore, a lightweight foam band was attached to the frame of the racquet, making the strung area smaller by covering the strung area nearest the frame. This results in a visible strung area approximately the size of the sweet spot, allowing these novices to be maximally aware of the success or failure of their stroke process.

Training was conducted using a basket of regular pressure tennis balls. The target area on a standard tennis court was marked out with plastic cones placed 8 inches apart from each other to create two circles as indicated in *Figure 1*. Flexible flat plastic strips were used to guide visual understanding of positioning.

Figure 1
Tennis Court Layout



X1=Subject starting position, X2 = Subject hitting position, PI=PI feeding balls, ◎= target area for struck ball.

Measures

Forehand accuracy. A test of participants' accuracy was designed for this study, the visual depiction of which can be seen in *Figure 1*. Participants earned two points for landing the ball in the large circle on its first bounce or four points for landing the ball in the small circle on its first bounce. These points were awarded for every one of the sixty attempts and were calculated from video-tape footage. Scores were summed for each of three practice phases - each comprised of twenty attempts. Scores therefore ranged from zero to eighty points for each practice phase for forehand accuracy. Video-tapes were reviewed by a research assistant who was a division one tennis player at a major private university in the North East. An inter-coder agreement of .96 was calculated for reliability of observations.

Foot and racquet placement. A test of players' ability to correctly position their feet and racquet was designed. The number of successfully executed foot and racquet placements was calculated by giving one point for correct placement of the feet and one point for correct placement of the racquet (see *Design and Procedure* section). As with the measure of forehand accuracy, points were awarded for every one of the sixty attempts and was calculated from video-tape footage. Scores were summed for each of three practice phases - each comprised of twenty attempts. Scores therefore ranged from zero to forty points for each foot and racquet placement practice phase. An inter-coder agreement of .89 was calculated for reliability of observations.

Hitting the sweet spot. A test of players' ability to hit the racquet's sweet spot will be designed. The number of shots hit with the sweet spot was calculated by giving one point for each (see *Design and Procedure* section). As with the measure of forehand accuracy, points were awarded for every one of the sixty attempts and were calculated from video-tape footage. Scores were summed for each of three practice phases each comprised of twenty attempts. Scores therefore ranged from zero to twenty points for each practice phases. An inter-coder agreement of .92 was calculated for reliability of observations.

Strategy attributions. This scale is an adaptation of the question asked by Zimmerman and Kitsantas (1997) regarding attributions based on dart throwing. The timing of this question was based on two criteria. First, the sixty practice attempts were divided into eight sub-groups. Then, following an attempt that missed the target area within each sub-group, the player was asked, *'Why do you think you missed the target area with the last shot?'* Answers were then categorized as *strategy attribution* or *non-strategy attribution*. Examples of non-strategy attributions were, 'I needed to try harder' and, 'I am no good at this'. An example of a strategy attribution was, 'I needed to hit the sweet spot'. One point was awarded for a strategy attribution, and zero for a non-strategy attribution, resulting in a total score ranging from zero to eight points (based on 8 attempts) for each player. An inter-coder agreement of .98 was calculated.

Stated goals. Novices were randomly assigned to different goal setting groups (see *Design and Procedure* section). In order to measure the extent to which players reacted to elements of the design and set either process or outcome goals, the following question regarding stated goals was asked directly after the seventh and fourteenth attempts of each practice phase, "What will you focus on most in the next few shots?" Answers were coded based on *Process Goal* responses, such as "I will try to hit the sweet spot", and *Outcome Goal* responses, such as "I will try to hit the target area." One point was awarded for a process goal response, and zero for a non-process goal response. Totals for each player, therefore, ranged from zero to six points. An inter-coder agreement of .98 was calculated for reliability of observations.

For the *Self-Shifting Group*, their stated goals also allowed for a measure of their point of shifting from process to outcome goals, which was compared to other experimental groups. Other experimental groups shifted in response to experimental control. The *Intermediate Process Group* shifted following twenty attempts, whereas the *Extended Process Group* shifted following forty attempts.

Self-efficacy. This question was adapted from the Zimmerman and Kitsantas (1997) measure of self-efficacy and was asked at the end of the third practice phase. Players were asked, "How sure are you that you can hit the ball in the target area using this shot? 10 means not sure at all, 40 means a little sure, 70 means quite sure, and 100 means totally sure." Players responded using an efficacy scale ranging from 10 (*not sure at all*), 40 (*a little sure*), 70 (*quite sure*), and 100 (*totally sure*).

Design and Procedure

Training phase. All participants viewed a modeling process of a beginner level forehand being hit by the PI (who is a qualified and experienced tennis instructor). As they viewed the specific sub-processes being modeled, each process was verbally explained to them as follows:

1. "From the ready position, begin by turning your body and racquet to the forehand side as the ball leaves the coach's hand" (represented as X1 in *Figure 1*). This was done to the right hand side for right-handed novices, and to the left for left-handed novices.

2. "Keep the racquet parallel to the net and slightly in front of you at waist height". Holding the racquet to the forehand side was awarded one point.

3. "Keep making quick steps as you approach the ball".

4. "When your racquet and ball are about to meet, stop moving your feet in a position so that they are sideways to the net. So stop before you hit the ball" (represented as X2 in *Figure 1*). One point was given if the feet of the player were stationary and sideways to the net prior to hitting the ball.

5. "As you make contact with the ball, move the racquet slowly upwards as though you were raising it over the net. Try to hit the middle of the strings called the sweet spot. Listen for the sound of that sweet spot as the ball hits it." All groups except the control group that focused only on outcome goals were told during the process phase, "When you see the racquet tapping the ball, say '*sweet spot'*. This was aimed at maintaining a process focus during the practice phase. Process-related verbalizations have been used successfully to maintain participants' attention on mental representations of key processes (Beilock, Carr, MacMahon, & Starkes, 2002). This type of verbalization is termed *skills focusing*. In the authors' expert-novice comparative study, soccer players learned to dribble a ball through a slalom course of cones. The

authors found that novices benefited from this process verbalization link, allowing them to maintain focus on the mental representation of these processes, enhancing skill development as a result. As mentioned in a previous section, they also found that experts suffered from verbalizing the sub-processes or techniques involved in the soccer drill in comparison to performances in the absence of skills focusing, and was attributed to the disruption of experts' proceduralized skill. One point was awarded for hitting the ball with the sweet spot.

6. "Tap the ball slowly by lifting your racquet just a bit above the starting position".

7. "You can think of this whole thing as '*racquet / stop / sweet spot'*.

8. "As you can see, the ball now moves slowly upwards off the racquet in an arc shape. It goes about 5 feet over the top of the net, and lands in the target area on the other side."

9. "Finally, return to the ready position when you are finished hitting the ball." The same stroke was repeated twice more with the succinct verbalizations, 'racquet / stop / sweet spot' uttered. This reinforced the sub-processes that were key to successful execution and point-scoring.

Practice Phase.

All novices then entered into a practice phase. Subjects were randomly assigned to the following groups: '*Outcome Goal Group'*, the '*Self-Shifting Group'*, the '*Intermediate Process Group'*, and the '*Extended Process Group'*. *Table 2* lays out the sequence of events for each group.

Outcome goal group. This group acted as a control group, and focused on outcomes (performance) throughout their practice. These participants were told that their objective was to focus on where the ball lands in relation to the target area (*Figure 1*). This group was asked to make attributions and set goals regularly during each series of strokes. Players made sixty attempts at the task, and awarded themselves two points for landing the ball in the large circle or four points for landing the ball in the small circle. This group tried to achieve the highest number of points received from accurately hitting the target.

Self-shifting group. Based on the Zimmerman and Kitsantas study (1997), players from the *Self-Shifting Group* shifted from process to outcome goals during their practice session. These researchers shifted the student at the point of automaticity, which was defined as performing the process strategy without errors for a certain number of trials. In the present study, the students' decided for themselves when to make the shift from process to outcomes. Players in this group were guided to focus on process goals, and verbalize '*sweet spot'* at the contact point to further ensure a focus on processes during execution. As with the *Outcome Goal Group*, players were told that they would make a total of sixty attempts. However, before they began practicing, they were told, "When you feel that you have learned how to do the forehand properly, let me know. Just tell me that you've got it. Then, I will tell you what will come next."

Once a player in this group decided that they had "got it," they were told to switch their focus to hitting the ball in the target area as much as possible, in other words, they switched to outcome goals. As with the *Outcome Goal Group*, players awarded themselves two points for landing the ball in the large circle or four points for landing the ball in the small circle. Upon switching to outcome goals, the group was told that they were no longer required to say 'sweet spot' at contact as they were no longer focusing on processes. This group tried to achieve the highest number of points received from accurately hitting the target.

Intermediate process group. This group of participants followed a similar protocol to the *Self-Shifting Group*, switching from process to outcome goals during their sixty attempts. These participants were prompted to focus on processes for a period of twenty attempts, at which time they were prompted to shift their focus to outcome goals. Players also verbalized '*sweet spot'* at the contact point to further ensure a focus on processes during execution prior to shifting.

Extended process group. This group of participants followed a similar protocol to the other process focus groups, switching from process to outcome goals during their sixty attempts. They were, however, asked to focus on the processes of the forehand for forty attempts, at which time they were prompted to shift their focus to outcome goals. Players also verbalized '*sweet spot'* at the contact point to further ensure a focus on processes during execution prior to shifting.

Table 2.
Group Procedure and Microanalytic Question Sequencing

Group	Goal Focus		
Extended Process	Processes (40 attempts)		Outcomes (20 attempts)
Intermediate Process	Processes (20 attempts)	Outcomes (40 attempts)	
Self-Shifting	Processes (self-determ	Outcomes (following shift)	
Outcome Goal	Outcomes (60 attempts)		
Number of Attempts	1-20	21-40	41-60
Practice Phase	1	2	3
Microanalytic Questi (same for all groups)			
		Goal State	
Number of Attempts	After 7 and 14	After 27 and 34	After 47 and 54
		Strategy Attributions	
Number of Attempts (following error)	Before 7, 14, 20	Before 27, 34, 40	Before 47, 54
		Self-efficacy	
Number of Attempts			After final phase

CHAPTER FOUR

RESULTS

Before undertaking the primary analyses for each dependent measure, a stepwise regression was conducted to determine whether the students' gender or grade was related to that dependent measure. If no significant effects were found, the data were combined across gender and grade for subsequent analyses. Overall differences among groups were analyzed using 4 (groups) x 3 (practice phases) analyses of variance (ANOVA). Significant mean effects or interactions were used using planned or post-hoc tests.

Table 3 displays the means and standard deviations for variables across all practice phases for each experimental group.

Table 3
Means and Standard Deviations Within Three Practice Phases for all Groups

Dependent Measures	Practice Phase	Independent Variables			
		Extended Process	Intermediate Process	Self-Shifting	Outcome Goals (Control)
Target Accuracy	1	9.20 (2.17)	8.60 (2.17)	11.00 (2.17)	10.40 (2.17)
	2	11.20 (1.93)	11.80 (1.93)	14.00 (1.93)	12.60 (1.93)
	3	22.20 (2.20)	12.00 (2.20)	15.60 (2.20)	13.80 (2.20)
Foot and Racquet Placement	1	21.40 (2.15)	20.40 (2.15)	22.20 (2.15)	21.90 (2.15)
	2	30.20 (2.26)	23.50 (2.26)	21.00 (2.26)	20.50 (2.26)

Dependent Measures	Practice Phase	Independent Variables			
		Extended Process	Intermediate Process	Self-Shifting	Outcome Goals (Control)
	3	31.70 (2.29)	22.40 (2.29)	21.50 (2.29)	22.00 (2.29)
Hitting the Sweet Spot	1	4.00 (1.10)	6.20 (1.10)	5.80 (1.10)	4.40 (1.10)
	2	8.00 (1.08)	7.70 (1.08)	6.50 (1.08)	5.00 (1.08)
	3	9.50 (1.08)	8.00 (1.08)	8.20 (1.08)	5.00 (1.08)
Stated Goal	1	1.40 (0.84)	1.30 (0.82)	1.60 (0.70)	0.80 (0.63)
	2	1.40 (0.70)	0.50 (0.71)	0.40 (0.70)	0.60 (0.70)
	3	0.80 (0.79)	0.20 (0.42)	0.00 (0.00)	0.50 (0.85)
Strategy Attributions	1	2.70 (0.95)	2.40 (1.07)	2.50 (0.53)	1.60 (0.97)
	2	2.80 (0.42)	1.30 (1.25)	1.30 (1.06)	1.20 (1.14)
	3	1.80 (0.42)	0.90 (0.57)	0.40 (0.52)	0.90 (0.88)
Self-Efficacy	3	54.80 (9.94)	43.60 (14.65)	57.90 (13.56)	61.80 (3.85)

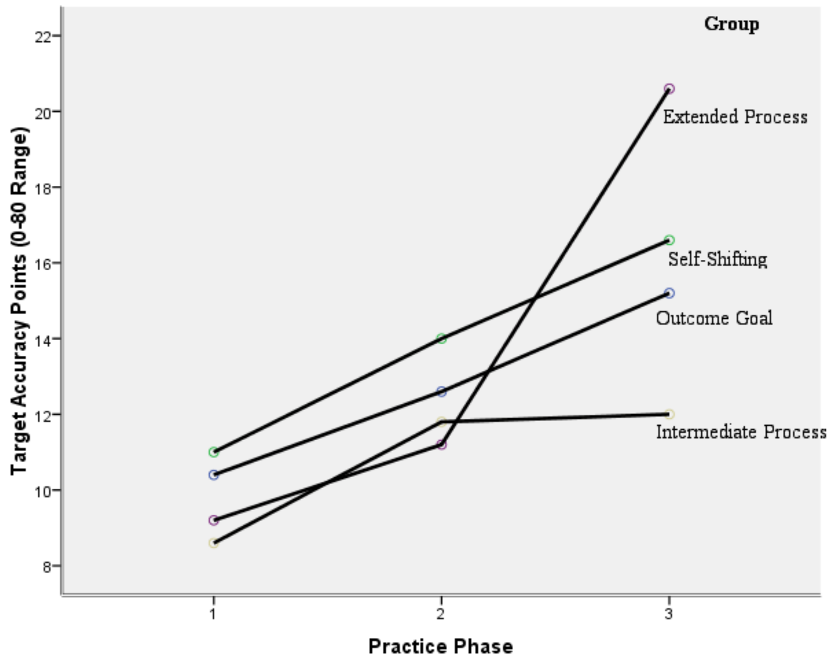
Behavioral Measures

For each of the behavioral measures, a regression analysis was first used to test for gender and grade effects. In the case of *target accuracy*, no significant effects were found for gender $F(1, 38) = 0.15$, $p = .70$, or grade $F(1, 38) = 0.09$, $p = .76$. The first tennis subprocess, *foot and racquet placement*, did not differ significantly on the basis of gender, $F(1, 38) = 0.08$, $p = .79$ or grade, $F(1, 38) = 0.01$, $p = .94$. The second subprocess, *hitting the sweet spot*, did not differ significantly on the basis of gender, $F(1, 38) = 0.40$, $p = .53$ or grade, $F(1, 38) = 2.10$, $p = .14$. In each case, the data were combined for subsequent analyses using 4 (group) X 3 (phase) analysis of variance (ANOVA).

Target accuracy. The results of the 4 X 3 ANOVA indicated a significant main effect for practice phases, $F(2, 35) = 12.21$, $p < .001$. There was no main effect for group, F (3, 36) = 0.82, but there was a significant interaction between practice phases and groups, $F(6, 70) = 2.27$, $p < .05$. As is evident in *Figure 2*, the results showed differences between the training groups across the practice phases. As predicted, there were no significant differences among groups following the first phase, that is, following twenty attempts at target accuracy, F (3, 36) = 0.25, p > .05. In addition, there were no significant differences among groups following the second phase, that is, following the 21st to 40th attempts, F (3, 36) = 0.87, p > .05. However, there were significant differences among the groups following phase three, that is, following the 41st to 60th attempts, F (3, 38) = 4.22, $p < .05$. Planned tests compared pairs of groups on target accuracy following the third practice phase. The target accuracy of the *Extended Process Group* was significantly greater than the *Self-Shifting Group*, $F(1, 18) = 4.57$, $p < .05$, the *Intermediate Process Group*, F (1, 18) = 11.13, $p < .05$, and the *Outcome Goal Group*, $F(1, 18) = 8.22$, $p < .05$. The differences in target accuracy among the self-shifting, outcome, and intermediate process groups were not statistically significant.

Figure 2

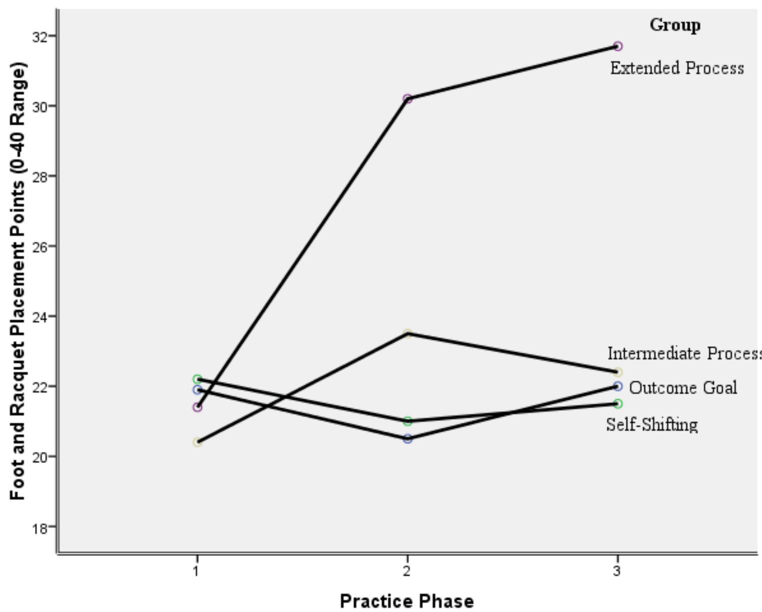
Comparing Groups on Target Accuracy Within Three Practice Phase



Foot and racquet placement. The 4 x 3 ANOVA showed no main effect for either experimental group or practice phase, but it did show a significant interaction between practice phases and group, $F(6, 70) = 4.63$, $p < .001$ (see *Figure 3)*. As was predicted, there were no significant differences among groups following the first phase, that is, following twenty attempts at target accuracy, $F(3, 36) = 0.14$, $p > .05$. There were significant differences among groups following the second phase, that is, following the 21st to 40th attempts, $F(3, 36) = 3.57$, $p < .05$. Post-hoc analyses using Tukey tests revealed significant differences between the *Extended Process* and *Outcome Goal Groups*, $p < .05$ and between the *Extended Process* and *Self-Shifting Groups*, $p < .05$. The differences between *Extended Process* and *Intermediate Process Group* narrowly missed statistical significance, $p < .06$.

Regarding the third phase, a priori tests revealed that *Extended Process Group* scored significantly higher than the *Self-Shifting Group,* F (1, 18) = 13.18, $p < .05$, the *Intermediate Process Group*, F (1, 18) = 11.57, $p < .05$, and the *Outcome Goal Group*, F(1, 18) = 12.31, $p < .05$.

Figure 3
Comparing Groups on Foot and Racquet Placement sub-Process in Each Practice Phase

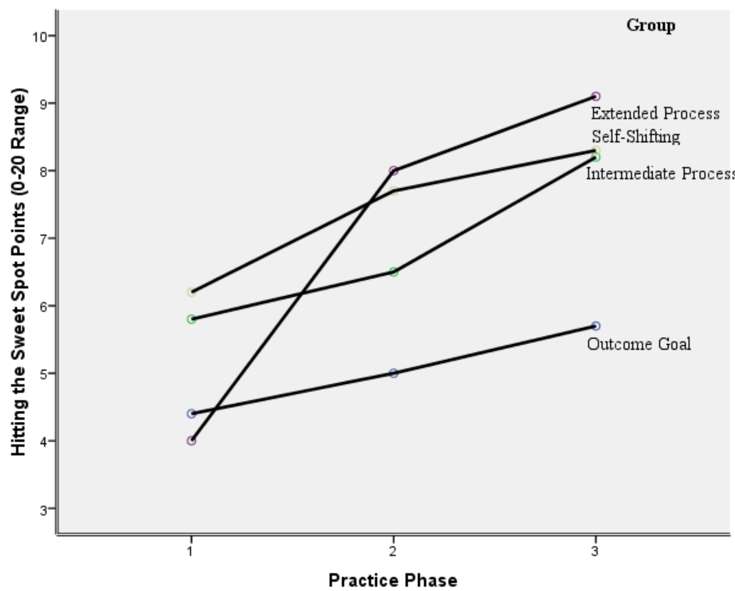


Hitting the sweet spot. The 4 X 3 ANOVA showed no significant main effect for either experimental group or phase, but there was a significant interaction between practice phases and groups, $F(6, 70) = 2.32$, $p < .05$ (see *Figure 4)*. As predicted, there were no significant differences among groups following the first phase, that is, following twenty attempts at target accuracy, F (3, 36) = 0.14. In addition, there were no significant differences among groups following the second phase, that is, following the 21st to 40th attempts, F (3, 36) = 1.18. Statistical differences among groups in phase three narrowly missed statistical significance, $p < .07$.

Planned comparisons revealed that the phase three mean of the *Extended Process Group* was not significantly higher than the *Self-Shifting Group,* $F(1, 18) = 0.78$ or the *Intermediate Process Group*, $F(1, 18) = 1.11$. However, the phase three mean for the *Extended Process Group* was significantly higher than the *Outcome Goal Group*, $F(1, 18) = 8.50$, $p < .01$.

Figure 4

Comparing Groups on the Sweet Spot sub-Process in Each Practice Phase

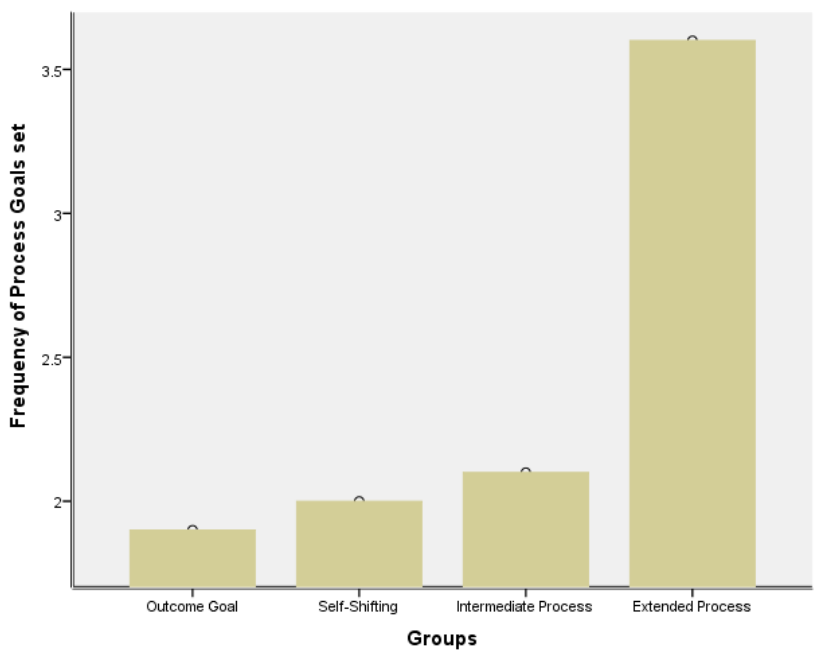


Self-Regulatory Processes

For each of the self-regulatory measures, a regression analysis was first used to test for gender and grade effects. In the case of *stated goals*, no significant effects were found for gender $F(1, 38) = 0.65$, $p = .45$, or grade $F(1, 38) = 2.90$, $p = .09$. In the case of *strategy attributions*, tests did not differ significantly on the basis of gender, $F(1, 38) = 0.06$, $p = .80$ or grade, $F(1, 38) = 0.07$, $p = .79$. *Self-efficacy* tests similarly did not differ significantly on the basis of gender, $F(1, 38) = 0.40$, $p = .53$ or grade, $F(1, 38) = 2.10$, $p = .14$. In each case, the data were combined across group and gender for subsequent analyses using univariate analysis of variance (ANOVA).

Stated goals. A single factor four experimental group ANOVA revealed a significant group effect, $F(3, 36) = 2.98$, $p < .05$ (see *Figure 5)*. Planned comparisons revealed that the *Extended Process Group* significantly surpassed the *Intermediate Process Group,* $F(1, 18) = 4.54$, $p < .05$, the *Self-Shifting Group*, $F(1, 18) = 5.74$, $p < .01$ and the *Outcome Goal Group*, $F(1, 18) = 7.58$, $p < .001$.

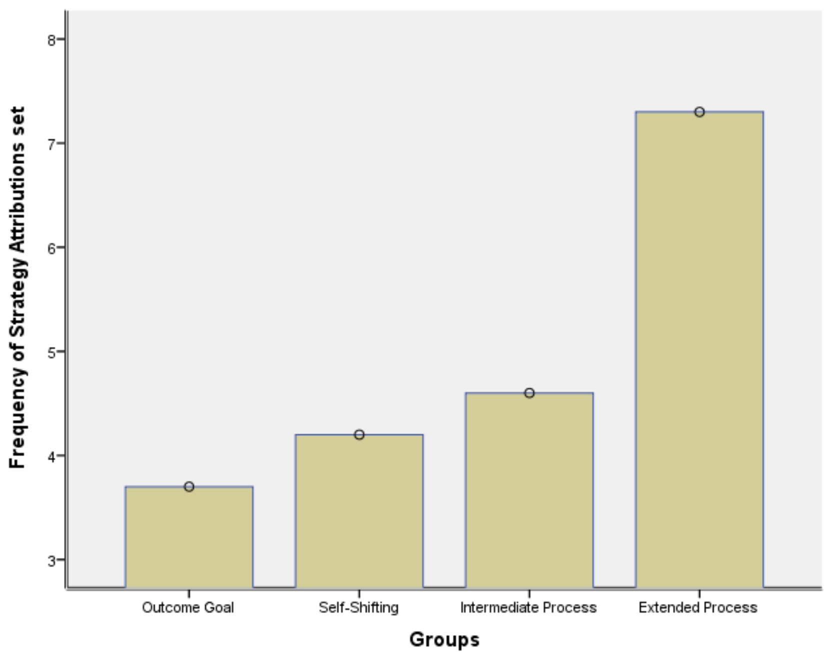
Figure 5
Total Process Goals set by Groups



Point of shifting from process to outcome goals. Regarding the average point at which the *Self-Shifting Group* shifted from process to outcome goals, a *mean* of 16 attempts resulted from this investigation. As predicted, this was significantly different from the point of shifting for the other experimental groups - the *Intermediate Process Group*, $F(1, 18) = 7.06$, $p < .05$, and also the *Extended Process Group,* $F(1, 18) = 254.12$, $p < .001$.

Strategy attributions. Regression analyses revealed no significant effects for gender $F(1, 38) = 0.37$, $p = .54$, or grade $F(1, 38) = 0.07$, $p = .79$ on strategy attributions, and thus the data were combined across group and gender for subsequent analyses. Overall comparisons of strategy attributions set by experimental groups were analyzed using a univariate analysis of variance (ANOVA). There was a significant main effect for group, $F(3, 36) = 9.12$, $p < .001$ (see *Figure 6)*. Planned comparisons revealed that the *Extended Process Group* set significantly more strategy attributions than the *Intermediate Process Group*, $F(1, 18) = 14.11$, $p < .001$, the *Self-Shifting Group*, $F(1, 18) = 20.04$, $p < .001$, and the *Outcome Goal Group*, $F(1, 18) = 39.86$, $p < .001$.

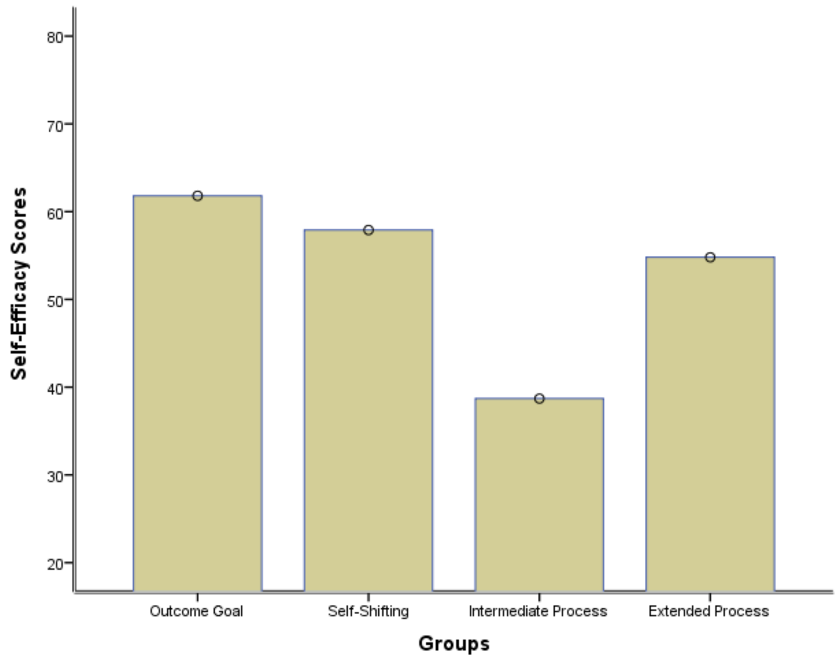
Figure 6
Total Strategy Attributions set by Groups



Self-efficacy. Regression analyses revealed no significant effects for gender $F(1, 38) = 0.37$, $p = .54$, or grade $F(1, 38) = 0.07$, $p = .79$ on self-efficacy, and thus the data were combined across group and gender for subsequent analyses. A pre-testing of group mean levels of self-efficacy was analyzed with a univariate analysis of variance (ANOVA). The test revealed no significant differences among groups, $F(3,36) = 0.71$, $p > .05$ (see *Figure 7*). However, during posttesting, there was a significant effect for group, $F(3, 36) = 4.79$, $p < .05$. According to

Tukey tests, the *Outcome Goal Group* had significantly higher levels of self-efficacy than the *Intermediate Process Group* ($p < .01$), the *Self-Shifting Group* had significantly higher levels of self-efficacy than the *Intermediate Process Group* ($p < .05$), and the *Extended Process Group* had significantly higher levels of self-efficacy than the *Intermediate Process Group* ($p < .05$). No other post-hoc tests were significant.

Figure 7
Group Self-Efficacy Scores



Exploratory Analysis of Automaticity

The *Extended Process Group* shifted from process to outcome goals after phase two, that is, following 40 attempts at the forehand. *Table 4* below outlines the mean scores for each group on their phase two sub-processes, that is, the phase after which all participants were performing using outcome goals. This allowed for a comparison of the relative level of mastery attained by each group following the same number of attempts at the forehand stroke, but leading to the point of shifting to outcome goals for the *Extended Process Group*. This builds on past research by Zimmerman and Kitsantas (1997) where participants shifted to outcome goals at a point of demonstrated mastery. In the current study, the level of mastery attained following extended practice was compared to the level of mastery attained by other groups who hit the same number of strokes, but who practiced processes for a lesser amount of time.

Table 4
Group Proportionate Success at Phase two Sub-Processes

	Phase two Sub-Processes	
Group	Foot and Racquet Placem	Hitting the Sweet Spot
Outcome Goal	20.5 / 40 (.51)	5.0 / 20 (.25)
Self-Shifting	21.0 / 40 (.53)	6.5 / 20 (.33)
Intermediate Process	23.6 / 40 (.59)	7.7 / 20 (.39)
Extended Process	29.0 / 40 (.73)	8.0 / 20 (.4)

Predicting Target Accuracy From Forehand Sub-Processes

First, overall target accuracy was predicted from overall foot and racquet and placement, and sweet spot measures. These measures together represented the forehand sub-processes, alternately called technique measures. These two predictors accounted for 21.4 percent of the variance in target accuracy (R^2 = .214), which was significant, $F(2, 37) = 5.08$, $p < .05$. Neither the foot and racquet placement (β = .224, *SE* = .125, *p*=.082) or sweet spot sub-processes (β = .395, *SE* = .276, *p*=.162) alone significantly predicted target accuracy.

It was hypothesized that Phase Three scores would prove theoretically distinct as skill development would take an extended period to emerge. As a result, target accuracy in Phase Three was then predicted from Phase Three scores for foot and racquet placement, and hitting the sweet spot. These two predictors accounted for 45.3 percent of the variance in target accuracy ($R^2 = .453$), which was significant, $F(2, 37) = 15.29$, $p < .001$. Foot and racquet placement ($\beta = .485$, $SE = .143$, $p = .002$) was a significant predictor, whereas sweet spot sub-processes ($\beta = .478$, $SE = .316$, $p = .139$) were not a significant predictor of target accuracy.

Predicting Target Accuracy From Strategy Attributions and Stated Goals

Overall target accuracy was regressed on overall strategy attributions and stated goals, followed by the same model from Phase Three measures. In the former model, the two predictors accounted for 1.9 percent of the variance in target accuracy ($R^2 = .019$), which was not significant, $F(2, 37) = .36$. Neither the strategy attributions ($\beta = .852$, $SE = 1.37$) or stated goal measures ($\beta = .258$, $SE = 1.85$) alone significantly predicted target accuracy.

Target accuracy in Phase Three was then predicted from strategy attributions and stated goals from the third phase. These two predictors accounted for 15.1 percent of the variance in target accuracy ($R^2 = .151$), which was significant, $F(2, 37) = 3.29$, $p < .05$. Stated goals ($\beta = 2.84$, $SE = 1.14$, $p = .05$) was a significant predictor, whereas strategy attributions ($\beta = .118$, $SE = .16$) was not a significant predictor of target accuracy.

Correlations Among Overall Measures

In order to determine the relationship among all overall measures, Pearson correlations were calculated, and the results are shown in *Table 5*. Subsequently, relationships among phase three measures were calculated, and the results are shown in *Table 6*. Forehand sub-processes in *Table 5* showed a significant relation with target accuracy. Hitting the sweet spot correlated significantly, $r = .38$, $p < .05$, as did foot and racquet placement, $r = .42$, $p < .01$. Finally, the sub-processes also correlated with each other significantly, $r = .48$, $p < .01$.

Most notably, forehand sub-processes in *Table 6* showed a significant relation with target accuracy and were more significantly interrelated than the overall measures. Hitting the sweet spot correlated significantly, $r = .53$, $p < .01$, as did foot and racquet placement, $r = .65$, $p < .01$. Finally, the sub-processes also correlated with each other significantly, $r = .59$, $p < .01$.

Table 5
Correlation Matrix for Overall Measures

	Variable	1	2	3	4	5	6
1	Target Accuracy	1					
2	Hitting Sweet Spot	.38	1				
3	Foot & Racquet Place	.42	.48	1			
4	Strategy Attributions	.14	.28	.40	1		
5	Stated Goals	.09	-.0[illegible]	.23	.55	1	
6	***Self-efficacy	.13	-.06	-.1[illegible]	-.0	.0[illegible]	1

* $p < .05$, ** $p < .01$, ***This represents overall measures only as it was not captured within phases

Table 6
Correlation Matrix for Phase Three Measures

	Variable	1	2	3	4	5	6
1	Target Accuracy	1					
2	Hitting Sweet Spot	.53	1				
3	Foot & Racquet Place	.65	.59	1			
4	Strategy Attributions	.23	.33	-.1	1		
5	Stated Goals	.41	.19	.06	.38	1	
6	***Self-efficacy	.38	-.04	.07	-.40	.20	1

* $p < .05$, ** $p < .01$, ***This represents overall measures only because it was not captured within phases

CHAPTER FIVE

DISCUSSION

The present study examined the effect of extended practice on young novice players' forehand skill development and performance. A micro-analytic method was employed to gather theory-informed data about key motivational and self-regulatory processes.

Group Differences in Target Accuracy

It was hypothesized that individuals who practiced for an extended period would be more accurate with their forehand than other groups, and that this difference would emerge following Practice Phase Three. In addition, the *Intermediate Process Group* was predicted to outperform the *Self-Shifting Group*, that would in turn outperform the *Outcome Goal Group*, and that these differences would also emerge in the third practice phase.

A practice phase effect was found which suggests that, overall, participants improved over time. No difference was found among groups following the first or second practice phase. Differences did emerge, however, following the third practice phase. More specifically, the *Extended Practice Group* was found to be more accurate than all other groups during this phase.

Contrary to hypotheses, no significant differences were found among other groups following the third practice phase. Motor learning is a complicated process involving several simultaneous moving components. In this study, the racquet, the body, and the ball were all moving at the same time with the aim of meeting at the correct contact point at the correct speed and angle. Experience led me to keep the challenge as uncomplicated as tennis would allow, while still keeping the findings valid by mirroring the moving parts involved in the game of tennis itself. The *Intermediate Process Group* switched to outcomes following the first practice phase. It seems participants simply did not engage in enough practice to master the processes. As a result, their accuracy improved little. For the *Extended Process Group*, motoric ability continued to improve during both the second and third phases.

A careful analysis of these results reveals that it is possible they more accurately reflect the hypothesis that the *Extended Process Group* would emerge as the more accurate performers by the third phase, but not before. The *Extended Process Group* had an extended period of practice in the absence of an outcome focus as compared to all other groups who were not given this opportunity, and so it follows that the other groups would possibly remain statistically similar on this measure.

Group Differences in Foot and Racquet Placement

It was hypothesized that the *Extended Practice Group* would display greater mastery of foot and racquet placement than other groups, and that this difference would emerge during the third practice phase. In addition, the *Intermediate Process Group* was predicted to outperform the *Self-Shifting Group*, that would in turn outperform the *Outcome Goal Group*, and that these differences would also emerge in the third practice phase.

Results revealed that, contrary to hypotheses, significant differences emerged between the *Extended Process Group* and all other groups by the second practice phase. These results were mirrored during the third practice phase, with the *Extended Process Group* far outperforming other groups on this skill measure, as indicated in *Figure 3*. Similar to the measure of target accuracy, no significant differences emerged among all other groups during all practice phases, contrary to hypotheses.

A notable distinction among groups in phase two is that the *Extended Process Group* alone maintained a process focus. All other groups had, by this phase, switched to outcomes either voluntarily in the case of the *Self-Shifting Group*, or, for other groups, in response to my requests. As *Figure 3* displayed, the differences by the second phase were stark. It would seem that the benefits of maintaining attention to processes were particularly apparent here as differences continued and indeed increased by the end of the third phase. This variable was measured prior to ball contact, and therefore involved movement more directly within the potential control of the participant. This direct control may have given participants who remained attentive to processes a significant learning advantage over the other participants.

Group Differences in Hitting the Sweet Spot

It was hypothesized that the *Extended Practice Group* would display greater mastery of hitting the sweet spot than other groups and that this difference would emerge during the third practice phase. In addition, the *Intermediate Process Group* was predicted to outperform the *Self-Shifting Group*, that would in turn outperform the *Outcome Goal Group*, and that these differences would also emerge in the third practice phase.

Differences among experimental groups were not as pronounced as the previous sub-process measure of foot and racquet placement. Although all experimental groups did improve over time and the *Extended Process Group* improved most of all as the hypotheses predicted, differences among experimental groups only approached significance. The *Outcome Goal Group* remained virtually unchanged over the course of their sixty attempts (see *Figure 4*), and tests revealed significantly more sweet spot strikes for the *Extended Process Group* when compared to the *Outcome Goal Group*.

The current study utilized the process verbalization ‘sweet spot’ at the point of contact with the aim of enhancing the development of the difficult skill of hitting the middle of the strings. Beilock, Carr, MacMahon, and Starkes (2002) showed that process-related verbalizations can be successfully used to maintain novices' focus of attention on mental representations of key processes. All process-focus groups used this tool, though it was used by the *Extended Process Group* alone during the second phase. This verbalization therefore lasted at least twice as long for participants practicing for an extended period in comparison to other participants. By controlling the attention of participants and directing it towards this difficult process of hitting the sweet spot for a much longer period of practice, it seems novices were better able to continue developing their skills.

Clearly, learning to coordinate the movement of the body and racquet with the movement of the ball to produce a sweet spot strike is greatly more difficult than coordinating the movement of the body and racquet alone. Indeed, professional tennis players are sometimes seen to "lift their head" prior to the contact of the racquet with the ball, resulting in miss-hits. This is reflected in scores on hitting the sweet spot being low overall with all groups scoring less than fifty percent of the time at hitting the sweet spot. More specifically, the *Extended Process Group* scored 0.48 of the time in the third practice phase, demonstrating the difficulty associated with learning this skill.

Taken together, these findings indicate lasting growth in skill development for novices who attend to processes for extended periods, and minimal growth for those who practice for significantly shorter periods. This emerging mastery proved sustainable in so far as skills continued to improve even when attention had shifted to outcomes after an extended period.

Relationship Between the two Process Variables and Target Accuracy

The relationship between the sub-process predictors and the outcome variable of target accuracy was explored. This examination was divided into 'combined phases' and 'third phase' analyses, guided by previous hypotheses that differences would be more perceptible during the third phase of the study. An analysis of combined phase scores revealed a significant relationship, with 0.21 of the variance in target accuracy explained by the two sub-processes of hitting the sweet spot and foot and racquet placement. Additionally, a significant correlation between the sub-process variables was revealed.

In Phase Three, the correlation between predictors was 0.65, explaining 0.45 of the variance in target accuracy. As other hypotheses suggested, phase three target accuracy proved to be more strongly related to the two sub-process predictors. By Phase Three, it seems, not only had differences between the groups emerged but also the relationship between learning and performance had become much more pronounced.

Group Differences in Stated Goals

It was hypothesized that the *Extended Process Group* would make greater use of process goals overall than the other groups. Goal orientation theorists (Elliot & McGregor, 2001; Cumming, Hall, Harwood, & Gammage, 2002; Harwood, Cumming, & Fletcher, 2003) view goal-directed behavior as stable over time. On the other hand, support for hypotheses in the current study was highlighted by Bandura, Zimmerman, and Schunk who posit greater fluidity in the learner's orientation to a task. In this way, adjustments are made to the demands of the environment across different situations and phases. This prompted further scrutiny of the issue.

The current study manipulated both the type and duration of players' goal states, thereby shedding light on the dynamic relation between learning processes and performance outcomes. Tests revealed significantly greater process goal setting by participants who practiced for an extended period, followed by the *Intermediate Process*, *Self-Shifting*, and *Outcome Goal* groups, respectively. Regression analyses predicting phase three target accuracy using stated goals revealed a significant beta weight of $\beta = 2.84$. The correlation between the two was 0.41 which was highly significant. This suggests that, indeed, a dynamic relationship exists between the use of goals and performance outcomes.

Point of Shifting From Process to Outcome Goals

A related prediction was that participants who determined for themselves when to shift from a process to an outcome-directed approach to the forehand task would do so prior to the other experimental groups. Additionally, it was hypothesized that this premature shifting would harm the *Self-Shifting Group's* learning and subsequent performance.

Tests supported the first hypothesis, with the *Self-Shifting Group* shifting to outcomes after an average of 16 practice attempts, compared to 20 and 40 attempts for the *Intermediate* and *Extended Process* groups, respectively. This supports the view that novices are prone to inadequately self-evaluate, leading to an optimistic evaluation of competence (Stipek & Tannatt, 1985; Newman & Wick, 1987).

The second hypothesis related to the outcomes associated with this shift. The *Self-Shifting Group* did indeed exhibit a lower standard of learning the forehand processes and hitting the target area than the *Extended Process Group*, though no differences were found with the other groups. This premature shift in focus prevented these novices from dedicating the time necessary to more completely learn and perform to a high standard. An extended period of practice was necessary to demonstrate a high level of learning and performance.

Group Differences in Making Strategy Attributions

It was hypothesized that participants from the *Extended Process Group* would make more strategy attributions following errors than other groups. This hypothesis built on past research by Kitsantas and Zimmerman (2002) which described how experts attribute failed performance to strategic processes more often. The authors determined that experts were, therefore, better able to control and alter processes with the goal of developing their skill. As procedures for this group were designed to mirror the habits of experts, a similar prediction was made. Tests revealed that, as predicted, the *Extended Process Group* was superior at attributing error to strategy than other groups.

Subsequent analyses explored the relationship between attributions and stated goals, and the degree to which strategy attributions predicted target accuracy. These exploratory analyses built on prior research by Zimmerman and Kitsantas (1999) who found that attributing failure to strategy lead to greater use of process-related adaptations. Attributions to strategy significantly correlated with the use of process goals overall (0.55), and within phase three (0.38), supporting prior research. Overall predictions of target accuracy from strategy attributions proved non-significant, however, as did phase three exploratory analyses.

Failure is clearly a common occurrence in skill development, but with the right instructional environment, novices are capable of making strategy attributions. From the current results, the relationship between strategy attributions and outcome measures is less clear, however.

Group Differences in Self-Efficacy

It was hypothesized that participants who practiced for an extended period would report higher levels of self-efficacy than other groups. This form of motivation both effects, and is affected by, performance. Therefore, it was believed that participants who performed well would display greater efficaciousness.

Contrary to hypotheses, no significant differences emerged between the groups. Post-hoc tests revealed results that were contrary to prior research, with the *Outcome Goal Group* reporting significantly higher levels of self-efficacy than others, despite the fact that they underperformed comparatively. Their responses may have demonstrated an inability to calibrate the degree of development that had been achieved. Novices regularly fail to accurately self-evaluate which can lead to inaccurate calibration of ability to self-judgments of competence (Stipek and Tannat, 1985, Newman & Wick, 1987).

An Analysis of Automaticity

As was noted earlier, automaticity has been defined as the point at which execution of a skill can be performed without deliberate attention (Feltovich, Prietula, & Ericson, 2006). In the present study, inferences about automaticity and its effects could be made at several levels: behavioral outcomes (i.e., target accuracy), tennis subprocesses (i.e., foot and racquet placement, and hitting the sweet spot) and self-regulatory processes (i.e., stated goals, attributions, and self-efficacy). Regarding behavioral outcomes, players in the *Extended Process Group,* which delayed automaticity the longest during practice, developed a significantly higher level of tennis accuracy than the other groups. In terms of tennis subprocesses (see *Table 4*), the *Extended Process Group* was also significantly more successful than the other groups in enhancing both foot and racquet placement (73 % success) and hitting the sweet spot (40% success). These two key subprocesses in tennis forehands predicted 21% of the variance in target accuracy, and thus, learners who focused the longest on learning processes displayed significantly higher scores on the tennis subprocesses measures and target accuracy.

In terms of the self-regulatory processes, players in the *Extended Process Group* set significantly more process goals and attributed errors to process strategies more often than learners in other groups. Although the results for the self-efficacy measures did not differ significantly between the *Extended Process Group* and *Outcome Goal Group,* self-efficacy beliefs did correlate significantly with students' target accuracy When considering the behavioral outcomes, tennis subprocesses, and self-regulatory processes together, novices who engaged in the briefest period of automaticity (i.e., *Extended Process Group*) consistently performed at a higher level.

Thus, the *Extended Process Group*'s lengthy focus on learning processes, coupled with its superior ability to attribute errors to strategy use, provided its members with greatest control over their practice and performance - even during the final outcome phase when automaticity was operative for all experimental groups. These findings support Zimmerman and colleagues' (Zimmerman & Kitsantas, 1999) contention that outcome goal setting affects the onset of automaticity and diminishes metacognitive control of key subprocesses in tennis. The results also support Ericsson and colleagues' (Feltovich, Prietula, & Ericson, 2006) emphasis on importance of deliberate practice in acquiring an expert level of performance. Clearly, delaying automatization enabled learners to develop a higher level of tennis forehand skill.

Educational Implications

Ericsson (2006) presented research that described expert behavior as being reproducible and superior to non-expert and novice behavior. This study showed that, to a large extent, specific expert habits such as deliberately attending to sub-processes to prevent arrested development, and attributing mistakes to controllable strategies so as to continue to make improvements, can be reproduced by novices when given the right environment to do so. Instructors should attempts to create an environment where strategies are modeled and verbalized widely by the teacher and by other students. For example, instructors should encourage the establishment of attention to learning processes for an extensive period prior to assisting their students in establishing outcome goals that assess performance. By regularly directing attention to goals, instructors can enhance learners' ability to attribute errors to strategy, thereby maximizing skill development and related self-motivations.

Zimmerman (2008) stated that, “goals motivate students’ choice of and attention to goal-relevant tasks” (p. 268). Only in bringing a specific task to one’s attention can one reflect upon and hope to improve it. This underlies the key component of self-regulation known as a feedback loop. By concentrating on process goals, novices deliberately directed attention to how the racquet, the body, and the ball were moving, and so were able to continue to improve in a dynamic fashion. Those who attended only to outcome goals were unable to display dynamic growth, incapable of using vital process-related information to feed back into their knowledge base, and instead became mired in arrested growth. While this study explored motoric skill development, instruction and research mirroring these procedures in educational settings might contribute to a challenged public education system that enforces accountability but does not teach students how to ’account’.

Limitations of the Study and Future Research

Self-efficacy scores given by students were not calibrated to actual performance, making it difficult to support or refute research that relates self-efficacy to variables such as past successes (Bandura, 1997). In the current study, novices attending only to outcomes underperformed in comparison to others, yet they expressed higher levels of self-efficacy, on average. Perhaps they simply were not aware of how to accurately judge their competence. The *Self-Shifting Group* made similarly far reaching judgments of competence even though their performance was far off the target in general. This presents the opportunity for future research to follow up on this line of questioning. Referencing the *Self-Shifting Group* in particular, who overestimated their ability and prematurely shifted to focusing on outcomes, while also overestimating their judgments of competence, future research should attempt to teach novices how to better monitor performance so that they can make more expert-like analyses of performance. If novice tennis players were taught how to improve the accuracy of their self-observation, the quality of their feedback should improve, and their self-efficacy should become better calibrated to ability. Consequently, novices may spend more time in self-regulatory cycles that would lead to greater improvement. This adaptive cycle of learning is vital to the proactive learner (Zimmerman, 2008).

Recognizing patterns of behavior that both help and hinder learning is vital to good instruction and intervention. This study supports the findings that novices tend to overestimate their abilities and underestimate the time needed to develop skills. Given the freedom to do so, novices in this study determined that they had learned the forehand significantly sooner than other experimental groups. This information can be used in future research to design ways to help novices make more 'expert' competence judgments with the aim of teaching them to spend extended time mastering a skill before they move on to evaluating the outcomes of that skill.

Becoming an expert requires significant guidance from more knowledgeable others. In addition, developing these skills requires a large portion of time practicing these nascent skills in the absence of overt instruction. Ultimately, it would greatly benefit novices to develop the skills that experts readily have at their disposal, resulting in a form of novice deliberate practice which mirrors the skills of the experts they may one day become.

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