

To the Graduate Council:

I am submitting herewith a thesis written by Tim Van Nguyen entitled “Self-Controlled Feedback and Activity Level in Learning a Simple Movement Skill.” I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of requirements for the degree of Master of Science, with a major in Sports Studies.

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SELF-CONTROLLED FEEDBACK AND ACTIVITY LEVEL IN LEARNING A SIMPLE
MOVEMENT SKILL

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Abstract

The purpose of this study was to determine if active and sedentary individuals differed in terms the effects of self-controlled feedback on the learning of a movement skill. The task consisted of a blindfolded beanbag toss using the non-preferred arm. Participants were pre-screened according to their physical activity level using the International Physical Activity Questionnaire (Craig et al., 2003). An equal number of active (A) and sedentary (S) participants were assigned to self-control (SC) and yoked (Y) feedback conditions, creating four groups: Self-Control Active; Self-Control Sedentary; Yoked Active; and Yoked Sedentary. SC condition participants were provided feedback whenever they requested it, while Y condition participants received feedback according to the schedule created by a SC counterpart to whom they were yoked. The SC condition was more accurate than the Y condition during acquisition and transfer phases. The A condition was more accurate than the S condition during all phases of the experiment. Results of a post-experimental questionnaire indicated that participants in the SC condition asked for feedback mostly after what they perceived to be “good” trials. Participants in the Y condition indicated that they would have preferred to receive feedback after “good” trials. This study provided further support for the advantages of self-controlled feedback when learning motor skills, additionally showing benefits for both active and sedentary individuals. In addition, the results suggested that the provision of experimenter-controlled feedback (i.e., in the Y condition) to sedentary learners degraded immediate performance. While this effect was not present during assessment of learning, it may have implications regarding the motivation of sedentary individuals to engage in practice when learning movement skills.

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CHAPTER 1

Introduction

Background of the Study

Self-regulation refers to how learners metacognitively, motivationally, and behaviorally participate in their own learning (Zimmerman, 1986). Interest in the role of self-regulation in motor learning stems from earlier considerations of how self-regulation might function in academic and sport settings (Hardy & Nelson, 1988; McCombs, 1989; Zimmerman, 1989). In the motor domain, self-regulation is thought to be associated with a person's efforts to control his or her own behavior (Chen & Singer, 1992) and so the term *self-control* has been frequently adopted in this research. Recent research has indicated that giving learners control over some aspect of an instructional protocol (i.e., video demonstrations, physical guidance, or augmented feedback) results in superior motor learning when compared to protocols that are completely prescribed by the researcher (for a review, see Wulf, 2007).

The provision of self-control during practice has been shown to enhance learning in studies investigating the effects of physical guidance and video demonstrations on tasks involving balance and object projection (Wulf & Toole, 1999; Wulf, Clauss, Shea, & Whitacre, 2001; Wulf, Raupach, & Pfeiffer, 2005). For example, Wulf and Toole allowed participants learning a ski simulator task to control when they used ski poles for guidance. Results revealed that the self-control condition performed with more proficiency during retention testing than did a yoked condition. Similarly, Wulf, Raupach, and Pfeiffer showed that a condition allowed to control the administration of video demonstrations performed more accurately and with better form than a yoked condition on a basketball jump shot.

The provision of self-control during practice has also been shown to be effective in studies manipulating augmented feedback (Janelle et al, 1995; 1997; Chen et al 2002; Chiviacowsky & Wulf, 2002, 2005, 2007; Chiviacowsky et al, 2008;). Janelle, Kim, and Singer (1995) examined the performance and learning of an underhand ball-toss. Participants in the self-control condition requested feedback about their movement form as often as they wanted while participants in the yoked condition were provided feedback according to a schedule matched to a corresponding participant in the self-control condition (i.e., they received feedback after the same trials). Results indicated that the self-control feedback condition performed more accurately during retention testing than the yoked condition. Similarly, Janelle et al. (1997) used a non-dominant arm overhand throwing task and found that the self-control condition was more accurate during retention testing than the yoked condition.

The provision of self-controlled feedback has also been found to facilitate the learning of a sequential timing task (Chiviacowsky & Wulf, 2002). The self-control condition did not differ from the yoked condition during retention testing, but did produce significantly less error in meeting the absolute timing goal during a transfer test which used a task that required a longer overall duration. Results from a questionnaire administered at the end of acquisition indicated that participants' preference for feedback was linked to their perceived success on a trial. Participants in the self-control condition indicated that they requested feedback after trials that they felt were successful. Interestingly, participants in the yoked condition indicated they did not receive feedback after the appropriate trials and that they would have preferred to receive feedback after successful trials.

The questionnaire results from Chiviacowsky and Wulf (2002) indicated that participants in the self-control condition believed that they were accurate in judging the success of a trial.

The authors suggested that the provision of self-control facilitated learning because it allowed the learners to tailor the administration of feedback to suit their individual needs or preferences during the learning process. Chiviacowsky and Wulf (2005) tested this idea by examining the performance and learning of a sequential timing task under two self-control conditions, one which requested feedback before a trial (self-before) and another which requested it after a trial (self-after). If the effectiveness of previous self-control manipulations depended upon the learner's assessment of his or her success on a trial, it would be expected that requesting feedback before a trial would not be as effective as requesting it after a trial. Results indicated that self-after condition was more accurate in terms of overall timing and relative timing than the self-before condition during a transfer test, which used a task requiring a longer overall duration. In a related study, Chiviacowsky and Wulf (2007) showed that learning was facilitated when knowledge of results (KR) was provided for the most accurate trials in a block compared to when it was provided for the least accurate trials.

Another interesting aspect of the self-control studies is that participants in the self-control conditions sometimes ask for assistance (i.e., demonstrations, guidance, or feedback) far less frequently than might be expected. Janelle and colleagues (Janelle et al., 1997; Janelle, Kim, & Singer, 1995) found that participants asked for feedback after less than 12% of trials. Wrisberg & Pein (2002) found that participants asked to see video demonstrations of the badminton long serve before only 9.8% of trials and that 82% of these requests occurred early during the first of three days of practice. In addition, 92% of the requests during the second and third days occurred during the first three trials (out of 31 total). Wulf and Toole (1999) reported that participants requested ski poles for guidance on a ski simulator task 92% of the time on the first trial, but only 25% of the time on the last trial.

Several explanations have been forwarded to account for how self-control manipulations work in motor learning. Janelle and colleagues (Janelle et al., 1997; Janelle, Kim, & Singer, 1995) argued that self-control fosters deeper information processing. Others have suggested that self-control may enhance participant motivation (McNevin, Wulf, & Carlson, 2000). Based on the evidence that participants reported asking for feedback after “good” trials, Chiviawsky and Wulf (2002) claimed that self-control feedback conditions allow learners to adopt a learning strategy based on the successful estimation of their own errors. In addition, they claimed that the requested feedback is used to confirm the participant’s success rather than correct errors. The relatively low number of requests for instructional assistance seen in several studies (e.g., Wrisberg & Pein, 2002) also suggests that learners understand when they need instructional support and that as they gain proficiency they should decrease their requests for assistance.

The self-control research in the motor domain may have implications for the implementation of exercise protocols when sedentary individuals attempt to learn new movement skills. Mullan and Markland (1997) reported that progress through stages of change in exercise behavior was related to self-regulation. It is unknown, however, if new exercisers need external regulation because they lack self-regulation in the first place, or if the lack of opportunity to exert self-control within typical exercise protocols undermines intrinsic motivation and/or learning. Self-determination theory (Deci & Ryan, 2000) suggests that the opportunity to self-regulate behavior will enhance intrinsic motivation to engage in that behavior. Furthermore, Chiviawsky and Wulf (2002, 2005) argued that self-control allows participants to tailor the instructional experience to match their individual needs and preferences for self-regulation. It is unknown whether sedentary individuals might prefer or need a greater degree of self-control than is normally afforded by typical exercise training protocols. One way of approaching this issue is

to first determine if the provision of self-control will benefit sedentary individuals learning a new movement skill. In addition, because active and sedentary individuals differ from one another on at least one dimension of behavior (i.e., physical activity), it is also possible that they differ in terms of the effectiveness of a self-control manipulation or their self-regulation preferences when learning a new movement skill.

Purpose of the Study

The purpose of this study was to determine if active and sedentary individuals differed in terms of the effects of self-controlled feedback on the learning of a movement skill.

Delimitations

The study was delimited by the following parameters:

1. Participants were 48 college-age males and females (24 male; 24 female).
2. Participants' ages ranged from 18-30 years.
3. The task was performed in a laboratory setting.
4. A criterion for inclusion in this study was that the participant had no formal experience in sports that required the projection of an implement using the upper extremities.

Assumptions

This study was based on the following assumptions:

1. All participants were motivated to perform the task according to instructions and to the best of their capabilities.

Research Hypotheses

The following hypotheses were based on previous research examining the effects of self-control feedback (Chiviackowsky & Wulf, 2002; 2005; Wulf, 2007):

1. During acquisition, all conditions will demonstrate increased accuracy across trial blocks.
2. During the 24-hour retention test, the self-control condition will perform more accurately than the yoked condition.
3. During the 24-hour transfer test (10 minutes after retention test), the self-control condition will perform more accurately than yoked condition.
4. Performance on trials for which feedback is requested will be more accurate than on trials for which it is not requested.

Exploratory Issues

Currently, there is no body of research literature on which to base hypotheses regarding differences between active and inactive participants in terms of task performance. Nevertheless, it was expected that active participants would perform more proficiently than inactive participants based on their higher levels of experience with movement skills and processing movement related to feedback. Based on the arguments formulated in the introduction it was likely that sedentary and active individuals also differed in terms of their preference for when they received feedback. Therefore, it was expected that there would be differences between active and sedentary individuals in terms of the frequency of feedback requests made during acquisition in the self-control condition. However, the exact nature of these differences (if they indeed existed) was unknown.

Definition of Terms

The following terms were defined as used in this study:

Absolute timing. Absolute timing was a measure of performance computed by taking the absolute difference between the overall goal movement time and the actual movement time (Chiviacowsky & Wulf, 2002).

Accuracy score. For the current study, the accuracy score was a measure of how close the participant's beanbag toss was to the center of the target. A lower score represented a smaller distance from the target.

Active. Active refers to participants who were classified as either *sufficiently active* or *health enhancing physically active* by their scores on the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003).

Acquisition. Acquisition refers to the period of the study during which the learner first acquired a new motor skill (also referred to as practice; Schmidt & Lee, 2005).

Beanbag toss. Beanbag toss refers to the experimental task used in this study. The beanbag toss required blindfolded participants to toss a beanbag at a target placed on the floor using their non-preferred arm. This task was similar to the one used in previous research on self-controlled feedback (Chiviacowsky & Wulf, 2007).

Feedback. Feedback refers to information given to the participant regarding the quality or results of his or her performance (Schmidt & Lee, 2005).

Frequency of feedback. For the current study, the frequency of feedback was a measure how many times a participant requested feedback in the acquisition phase.

Intertrial interval. Intertrial interval refers to the elapsed time from the conclusion of one trial until the beginning of the next trial (Schmidt & Lee, 2005).

Knowledge of results (KR). KR is feedback provided to a participant after completing a trial about a movement outcome relative to the goal of the task (Schmidt & Lee, 2005).

Movement time. Movement time is the elapsed time from the beginning to the end of a movement (Schmidt & Wrisberg, 2008).

Relative timing. Relative timing is a measure of the fundamental timing structure or rhythm of a movement, in which the ratios among the durations of various components of the movement are stable (Schmidt & Wrisberg, 2008).

Retention. Retention refers to the period of the study during which the learner is tested on what they have learned in acquisition. Retention usually occurs at some time after acquisition and involves the same tasks that were practiced during acquisition. No feedback is given during retention testing (Schmidt & Lee, 2005).

Sedentary. Sedentary refers to participants who were classified as *inactive* by their scores on the IPAQ (Craig et al., 2003).

Self-control. Self-control refers to a condition in the study in which participants decided when they would receive feedback after a trial (Janelle et al. 1997).

Transfer. Transfer refers to the period of the study during which the learner is tested on how well he or she can transfer to one or more novel motor skills related to those practiced during the acquisition phase (Schmidt & Lee, 2005).

Trial type. For the current study, trial type refers to the categorization of trials according to whether participants in the self-control condition did or did not request feedback. Feedback trials were those for which feedback was requested while no-feedback trials were those for which feedback was not requested. Feedback and no-feedback trials were also referred to as “good” and “bad” trials, respectively when discussing participants’ reasons for when they requested feedback (i.e., mostly after trials perceived to be “good”).

Yoked. Yoked refers to a condition in the study in which participants were matched with a counterpart in the self-control condition with respect to the trials after which feedback was administered. This condition is used in self-control studies to balance the frequency of feedback requests across conditions, so that each pair of participants in the self-control and yoked condition receives the same amount of feedback (Wulf & Toole, 1999).

CHAPTER 2

Literature Review

Self-Controlled Video Demonstrations

The effects of self-control have been examined for instructional manipulations involving the use of video demonstrations. Wrisberg and Pein (2002) used a task in which participants learned a badminton long serve. Participants were randomly assigned to one of three conditions. In the ALL condition, participants were shown a video of a model demonstrating the badminton long serve prior to each service attempt during a three-day practice phase. The LC condition viewed the video demonstration whenever they desired during practice. The NM condition did not see the demonstration. Performance was measured in terms of accuracy and form relative to the model. The acquisition phase consisted of three days of practice involving 31 trials on each day. The retention phase consisted of 11 trials and was conducted on the fourth day.

During acquisition, the accuracy of all three conditions improved significantly across practice trials. In addition, the LC condition was significantly more accurate than the NM condition. In terms of the form scores, the LC condition improved across each of the three days and the ALL condition improved from the second to third days. The NM condition did not show improvements across days. Both the LC and ALL conditions had better form scores than the NM condition. During retention testing on the fourth day, no significant effects were found for accuracy. In terms of the form scores, both the LC and ALL conditions had better scores than the NM condition. Although the LC and ALL conditions did not differ from one another, the authors noted that allowing learners to self-select their viewing of the demonstration improved instructional efficiency because the LC condition only requested feedback on 9.8% of the total trials, with 82% of requests occurring during the first half of the first day of practice.

Wulf, Raupach, and Pfeiffer (2005) investigated the effectiveness of self-controlled video demonstration on the learning of a basketball jump shot by participants who were unfamiliar with the task. Both shot accuracy and movement quality were examined. Participants were assigned to either self-control or yoked conditions. The self-control condition was free to watch the video demonstration as often as they wanted during the practice phase. Participants in the yoked condition were shown demonstration according to a schedule that matched the requests made by a counterpart in the self-control condition. The acquisition phase consisted of 25 practice trials. A retention test consisting of 10 trials was administered a week later. During acquisition, participants in the self-control condition requested the demonstration from one to three times, with an average of 1.5 requests. Similar to Wrisberg & Pein (2005), most requests were made early during the practice phase. In terms of both accuracy and form, the self-control and yoked conditions improved across trial blocks, but did not differ from one another. During retention, no significant effects were found for accuracy, but the self-control condition scored significantly higher form ratings than the yoked condition. The authors suggested that the self-control manipulation may have been effective for a number of reasons consistent with previous explanations regarding self-regulation and self-control. It may have increased motivation or engagement (e.g., McCombs, 1989), or allowed participants to match the scheduling to their individual preferences (Chiviacowsky & Wulf, 2002). In addition, the authors argued that the effects may have been due to more effective use of information in the demonstrations as has been suggested by previous work on observational learning (e.g., Scully & Newell, 1985).

Self-Controlled Physical Guidance

Other studies have examined the influence of self-control on the effectiveness of physical guidance for learning. Wulf and Toole (1999) investigated the effects of self-control of the use

of ski poles (guidance) on learning a ski simulator task. Participants were randomly assigned to either a self-control condition or a yoked condition. The self-control condition was encouraged to use the poles whenever they wanted. Participants in the yoked condition were given the poles according to a schedule matched to one created by a counterpart in the self-control condition. During acquisition, all participants practiced seven 90-second trials on each of two consecutive days. A retention test was administered on the third day and consisted of seven trials without poles.

During acquisition, both the self-control and yoked conditions improved their performances across the two days of trials, but there was no difference between the two conditions. During retention, the self-control condition performed significantly better than the yoked condition. Because there were no performance differences during acquisition but the self-control condition showed significantly better performance during retention, the authors suggested that the self-control participants may have engaged in a different information-processing activities than their yoked counterparts. Additionally, the authors suggested that self-control might have increased participant motivation (Bandura, 1997). The performance of the yoked condition was similar during the end of acquisition and retention while the self-control condition actually improved. The authors argued that participants in the yoked condition may have found the task less intrinsically motivating (Hardy and Nelson, 1988) due to a lack of opportunity for self-control.

Wulf et al. (2001) further investigated the effectiveness of self-control on a ski simulator task in dyad practice. Participants were randomly assigned to either self-control or yoked conditions. The participants practiced in dyads on 2 consecutive days. A dyad consisted of a self-control participant and a yoked participant practicing together. The participant in the self-

control condition decided when to use the poles while the other person performed according to the same pole/no pole schedule. The procedures for this study were similar to the procedures used by Wulf and Toole (1999) with the exception the use of the dyad practice procedure. For each dyad, the self-control participant performed the task on the first trial while the yoked participant watched and then they switched on trial two and so forth alternating for a total of seven observed and seven performed trials on each of two days of practice. During retention, participants were tested individually without poles.

During acquisition, results were similar to Wulf and Toole (1999) in that both groups improved their performance across the two days of practice. Additionally, there were no differences between the groups during acquisition. During retention, results revealed that the self-control group produced significantly later relative force onsets than the yoked condition, which indicated a more efficient pattern of shifting weight from one leg to the other (Wulf, Shea & Whitacre, 1998). There were no differences between the groups in terms of the amplitude and frequency of the movements. The authors suggested that observational learning may have negated the effects of self-control on movement amplitude seen in Wulf and Toole. Based on the relative force onset findings, the authors argued that giving learners the opportunity or responsibility to control part of the practice protocol may encourage them to search for “optimal task solutions”.

Self-Controlled Augmented Feedback

The effectiveness of self-control for motor learning was first demonstrated by Janelle and colleagues (Janelle, Kim, & Singer, 1995; Janelle et al., 1997). Janelle, Kim, and Singer examined the effects of self-control of augmented feedback for learning a task that required participants to underhand toss a golf ball at a target placed on the floor. Participants were

randomly assigned to one of five different experimental conditions. The performance summary condition was provided with performance feedback (i.e., regarding form) after every fifth trial. The fifty percent condition received performance feedback after every other trial. The subject-controlled condition was provided feedback as requested by the participant. The yoked condition was matched to subject-controlled condition. The control condition received no feedback.

During acquisition, each condition completed four trial blocks (10 tosses each). Feedback regarding throwing technique was presented verbally. After a 10-minute rest, participants completed a two-block retention test (10 tosses each for each block) without feedback. Results indicated that during acquisition, all conditions significantly improved across blocks. There were no differences between conditions. Retention results indicated that participants in the subject-controlled condition significantly more accurate than all the other conditions. This finding supported the idea that the provision of self-control facilitates the effective use of feedback information in learning a motor skill.

In a follow up study, Janelle et al. (1997) examined the effects of self-controlled feedback on a more complex task, which required participants to throw a ball overhand at a target using their non-dominant arm. Participants were randomly assigned to one of four experimental conditions. The knowledge of results condition (KR) received no augmented feedback but was able to see the outcome of the throw. The summary condition (SUMMARY) received feedback after every five trials consisting of a video replay of the throw and verbal feedback regarding throwing form. The self-control condition (SELF) received video and form feedback when they requested it. The yoked condition (YOKE) received feedback in schedules matched to the SELF condition. Acquisition consisted of 20 10-trial blocks while retention and transfer each consisted of one 10-trial block.

During acquisition, results revealed that the SUMMARY, YOKE and SELF conditions performed similarly while the KR condition performed significantly worse in terms of throwing form and speed. During retention and transfer, results revealed that the SELF condition performed with significantly better form than all of the other conditions. In addition, the SUMMARY condition performed with better form than the YOKE condition and the YOKE condition performed with better form than the KR condition. The results also revealed that men had a slightly higher rating on throwing form and throwing speed than women during both acquisition and retention. The authors concluded that this was due to the fact that men generally have more experience than women with throwing. Another interesting finding from both of the studies by Janelle and colleagues (Janelle, Kim, & Singer, 1995; Janelle et al., 1997) was that the self-control conditions requested a relatively low frequency of feedback (7% and 11.15%) during acquisition but still outperformed all other experimental conditions. The authors suggested that these results support the “guidance hypothesis” which indicates that a high frequency of feedback during the learning phase produces dependency and undermines learning (Salmoni, Schmidt, & Walter, 1984).

Another illustration of the benefit of a self-controlled feedback schedule on motor learning was a study done by Chiviacowsky and Wulf (2002). Participants learned a sequential timing task which required that they sequentially press the ‘2’, ‘4’, ‘8’, and ‘6’ keys on a computer keypad in a specified goal movement time. During acquisition and retention, the overall goal movement time was 900 ms. In addition, the first, second, and third segments were to be completed in 200 ms, 400 ms, and 300 ms, respectively. During transfer, the relative ratio of segment times (i.e., relative timing) was preserved, but the overall goal time was scaled to 1350 ms. The goal times for the first, second, and third segments were 300 ms, 600 ms, and 450

ms, respectively. Participants were randomly assigned to either a self-control or a yoked condition. Acquisition consisted of six 10-trial blocks. Retention and transfer tests were administered after 24 hours and each consisted of one 10-trial block. At the conclusion of the transfer test, participants completed a questionnaire regarding the administration of feedback.

During acquisition, results revealed that both the self-control condition and the yoked condition improved significantly across blocks. There were no significant differences between conditions during either acquisition or retention. During transfer, however, the self-control condition was significantly more accurate than the yoked condition. The results from the questionnaire revealed that participants in the self-control condition requested feedback after they thought they had a “good” trial (10 of the 15 participants). In addition, the majority of the self-control participants did not ask for feedback after a “bad” trial (11 of the 15 participants). In the yoked condition, 11 of the 15 participants indicated that they did not receive feedback on the right trials and the majority of those participants (7) said they would have preferred to receive feedback after “good” trials. To test the merit of participants’ reports regarding of “good” and “bad” trials, feedback trials were compared to no-feedback trials. Results revealed that the self-control condition was significantly more accurate than the yoked condition on the feedback trials (i.e., “good” trials), but not on the no-feedback trials (i.e., “bad” trials). Although not compared statistically, cell means suggested that the self-control condition performed better on feedback trials than on no-feedback trials. In contrast, the yoked condition performed better on the no-feedback trials. The authors suggested that this provided preliminary evidence that learners have the capability to assess their own performance and that the requests for feedback after “good” trials contradicted the guidance hypothesis (Salmoni, Schmidt, & Walter, 1984). The benefit of

the self-control manipulation was attributed to the idea that such a schedule was more tailored to the individual preferences and needs of the learners in the self-control condition.

Chen, Hendrick, and Lidor (2002) also conducted a study in which participants learned a sequential timing task. The task required participants sequentially press the '5', '2', '4', '6', and '8' keys on a computer keypad in 800 ms. Participants were randomly assigned to one of four conditions. Two conditions were allowed self-control over the administration of feedback. The self-initiated knowledge of results condition (SI-KR) received KR regarding their time if they depressed a button within three seconds after a trial. The experimenter induced knowledge of results condition (EI-KR) was similar the SI-KR condition with the additional provision of a reminder (i.e., "Do you want to know your performance results?"). The other two conditions were yoked to match the SI-KR and EI-KR conditions. During acquisition, participants completed 60 trials. An immediate retention test consisting of 20 trials was administered after a 5-min delay. Two days later, a second 20-trial retention test was administered. No feedback was provided during either retention test. During acquisition, results revealed that all conditions improved significantly across the first two of six trial blocks, with no further changes after that point. During both the immediate and 2-day retention tests, results revealed that the both self-control conditions (SI-KR and EI-KR) were significantly more accurate than the yoked conditions. Interestingly, both the SI-KR and EI-KR conditions requested feedback much more frequently (95% and 99%, respectively) than earlier studies. The authors suggested that the timing task was more difficult and that participants were more likely to have still been in early stages of learning. As with earlier studies, the effects of self-control were thought to be due to enhanced motivation to learn.

Chiviacowsky and Wulf (2005) conducted a study to examine the idea that self-controlled feedback was better tailored to the learner's needs or preferences. The task was the same timing task used in Chiviacowsky and Wulf (2002). Participants were randomly assigned to two self-control conditions. The self-after condition requested the completion of a trial while the self-before condition was required to make their feedback request before completing the trial. If the benefits of self-control seen in previous feedback studies were due to motivation, then both conditions should have performed similarly. In contrast, if the benefits of self-control were due to receiving feedback when it was most needed, then the performance of the self-after condition should have performed better than the self-before condition. During acquisition and retention, no differences were observed between the two conditions. During transfer, however, the self-after condition was significantly more accurate than the self-before condition. These results indicated that the benefits of self-control manipulations might not be due to motivation. The authors argued that the benefits of self-control were instead due to the learner's decision-making processes related to error estimation, which facilitated independence from extrinsic feedback.

Chiviacowsky and Wulf (2007) provided further support that the effects of self-controlled feedback were related to the success of the trial for which feedback was requested. Participants learned to toss a beanbag at a target placed on the floor using their non-dominant arm while blindfolded. The target was a 10-cm radius circle surrounded by larger concentric circles in 10-cm increments (i.e., 20, 30, 40, 50, 60, 70, 80, 90, and 100 centimeters). The target and surrounding circles created 10 scoring zones ranging from 100 points (target) to 0 points (outside the 100-cm circle). Participants were randomly assigned to two conditions. The KR-good condition received feedback about the three most accurate tosses in each block of six trials. The KR-poor condition received feedback about the three least accurate tosses. Participants were not

informed regarding the condition to which they were assigned. During acquisition, participants completed 10 blocks of six trials (60 trials total). During a 24-hour retention test, participants completed one 10-trial block without feedback.

During acquisition, results revealed that the both conditions improved their accuracy, but there was no difference between conditions. During retention, the KR-good condition was significantly more accurate than the KR-poor condition. These findings supported the idea that self-control feedback manipulations are mediated, in part, by the success of the trials for which feedback is requested. Furthermore, because participants in this study did not request feedback based on the estimation of their own errors, the authors argued that the results provided more evidence against the idea that feedback is most beneficial when errors are relatively large.

Explanations of Self-Controlled Practice

Several explanations have been forwarded to explain how self-control manipulations work in motor learning. Janelle and colleagues (Janelle et al., 1997; Janelle, Kim, & Singer, 1995) argued that self-control fosters deeper information processing because learners who feel they are in control may be more engaged in the learning process. Additionally, in self-control condition learners are free to engage in learning strategies that are most comfortable for them. Others have suggested that self-control may enhance participant motivation (McNevin, Wulf, & Carlson, 2000). Based on the evidence that participants reported asking for feedback after “good” trials, Chiviawosky and Wulf (2002) claimed that self-control feedback conditions did not operate through enhanced motivation, but instead allowed learners to adopt a learning strategy based on the successful estimation of their own errors. In addition, they claimed that requested feedback is used to confirm the participant’s success rather than correct errors. The relatively low number of requests for instructional assistance seen in several studies (e.g.,

Wrisberg & Pein, 2002) also suggests that learners understand when they need instructional support and that as they gain proficiency they should decrease their requests for assistance.

Implications of Self-Controlled Research

The self-control research in the motor domain may have implications for the implementation of exercise protocols when sedentary individuals attempt to learn new movement skills. In their cognitive evaluation theory, Deci and Ryan (1985) discuss motivationally based phenomena that address the effects of social contexts on intrinsic motivation. The premise behind cognitive evaluation theory is that if you give a learner the opportunity for self-regulation (e.g., by allowing self-control of some aspect of instruction), intrinsic motivation is increased and the need for external regulation (e.g., through rewards or reinforcement) is decreased. Increased intrinsic motivation, in turn, increases the desired behavior (e.g., engaging in the processes that support learning a movement skill). Allowing participants self-control during the learning of a movement skill rather than restricting their opportunities to self-regulate through the use of an instructor-controlled protocol may facilitate deeper involvement in the learning process. Deci and Ryan's work also implies that simply providing the opportunity for self-control may allow people who are initially low on intrinsic motivation to practice the self-regulation skills that will ultimately foster a higher degree of intrinsic motivation.

Mullan and Markland (1997) explored the relationship between self-determination in the regulation of exercise behavior and stages of change for exercise. Participants were 314 individuals (156 female; 158 male) who completed the *Stages of Change for Exercise Behavior Questionnaire* and the *Behavioral Regulation in Exercise Questionnaire* (BREQ) (Craig et al., 2003). The *Stages of Change* instrument indicates whether an individual is in the precontemplation, contemplation, preparation, action, or maintenance stages related to exercise

behavior. The BREQ instrument measures the degree to which an individual is more or less self-determined in the regulation of his or her behavior. The results revealed that participants that the BREQ subscales measuring intrinsic motivation and self-regulation successfully discriminated between stages of change. Participants in the action and maintenance stages scored higher on these subscales than participants in the earlier stages. Moreover, the composite score from the *Stages of Change* instrument showed that participants in the action and maintenance stages scored significantly higher in self-determination than those in the preparation stage which, in turn, scored significantly higher than those in precontemplation and contemplation stages (which were combined into a single stage for the analysis). Mullan and Markland cautioned that the nature of their study did not allow for a conclusion that participants became more self-determined as they progressed through the stages of change. At this time, it is still unknown if new exercisers need external regulation because they lack self-regulation in the first place, or if the lack of opportunity to exert self-control within typical exercise protocols undermines intrinsic motivation and/or learning. The latter possibility would be consistent with Deci and Ryan's (1985, 2000) arguments that external regulation undermines intrinsic motivation because it is controlling.

As a first step in addressing this issue, it would be important to determine if sedentary individuals differ from active individuals in terms of the effects of self-control on learning a movement skill. Because sedentary individuals may not have much experience with movement skills, the acquisition of such skills may be one of the challenges they face upon entering an exercise program. In the motor domain, self-control has been shown to enhance the learning of motor skills when compared to externally regulated conditions (i.e., yoked). Chiviacowsky and Wulf (2002, 2005) argued that self-control allows participants to tailor the instructional

experience to match their individual needs and preferences for self-regulation. It is not yet clear whether sedentary individuals might prefer or need a greater degree of self-control than is normally afforded by typical exercise training protocols. One way of approaching this issue is to first determine if the provision of self-control will benefit sedentary individuals learning a new movement skill.

CHAPTER 3

Method

Participants

Participants were 48 college-age volunteers (24 male; 24 female) recruited from the University of Tennessee, Knoxville Campus. The average age of participants was 21.31 years ($SD = 2.73$ years). All but four were right handed. Prior to the experiment, all participants read an informed consent document (Appendix A) that was approved by the University of Tennessee Institutional Review Board. None of the participants had any prior experience with the experimental task or procedures. Participants were screened to exclude those with past experience in sports and activities that require the projection of an implement using the upper extremities (e.g., baseball, shot put, or javelin).

Apparatus and Task

The task was similar to the one used by Chiviacowsky & Wulf (2007). It required blindfolded participants to toss a beanbag (100 gram) with their non-preferred arm at a target placed on the floor (see Figure 1). Participants were told to hit the center of the target. The target was a circle with a radius of 10 cm painted on a piece of cloth, which was secured to the floor. Nine additional concentric circles with radii of 20, 30, 40, 50, 60, 70, 80, 90, and 100 centimeters, respectively, were also painted on the cloth. A line marking the location from which participants tossed the beanbag was placed on the floor at a distance of three meters from the center of the 10-cm target. Each toss was scored using a point system in which zero points were awarded for landing on the target (i.e., the 10-cm circle). The score was increased by 10 points for each successive circle moving away from the center of the target, such that a lower score indicated more accurate performance.

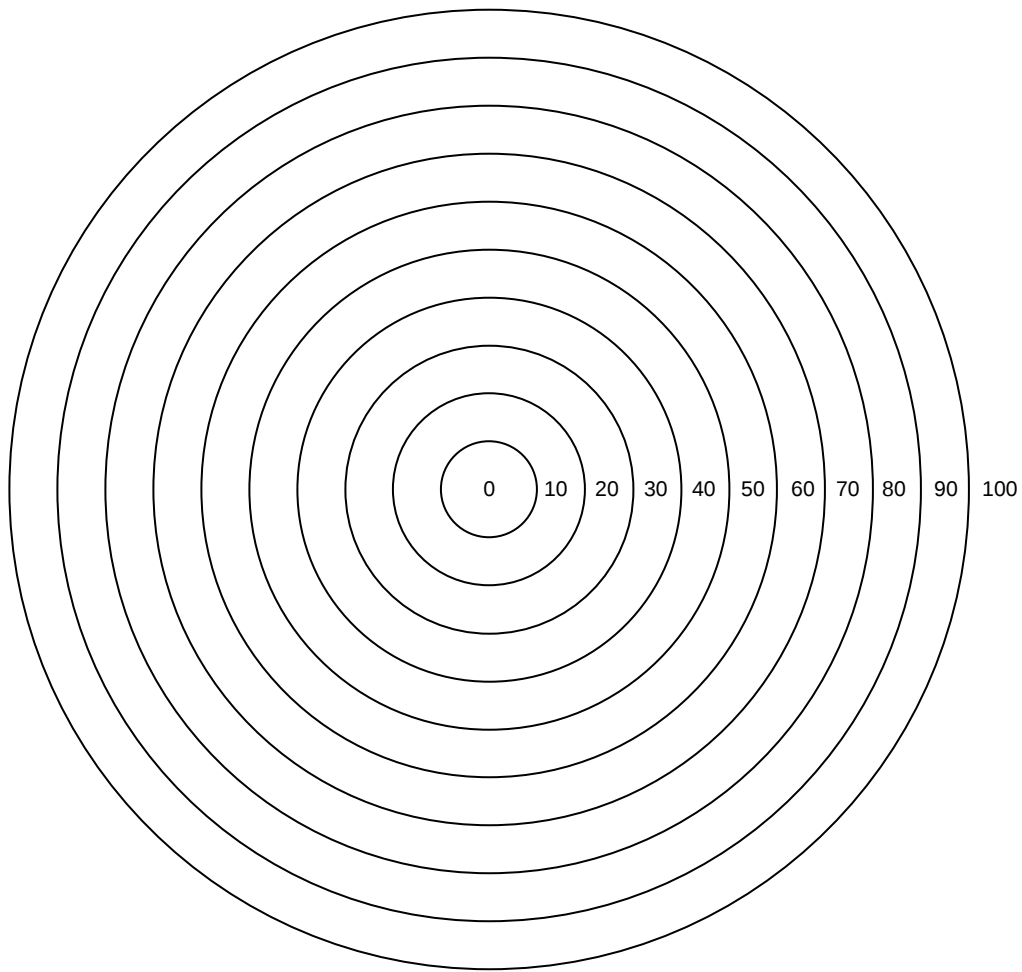


Figure 1. Diagram of the target and surrounding scoring rings, with point value of each ring indicated. Target circle (center) was 10 cm in radius. Each successive ring moving away from the center was an additional 10 cm in radius.

Pilot Study

A pilot study involving five participants was completed to familiarize the primary investigator with the experimental procedures and to identify potential problems with the procedures and data recording methods.

Procedure

Upon arriving to the laboratory, participants read and signed an informed consent (see Appendix A) and were then given written instructions (see Appendix B). Participants were assigned to one of two groups according to an initial screening of their level of physical activity using the International Physical Activity Questionnaire (IPAQ; Craig, et al. 2003; Appendix C). Participants were assigned to either an active (A) group or a sedentary (S) group. Participants in each of these groups were then randomly assigned to either a self-control feedback condition (SC) or a yoked condition (Y) to create four groups (SC-A; SC-S; Y-A; and Y-S). Participants were yoked man-to-man, woman-to-woman, sedentary-to-sedentary, and active-to-active.

Prior to the acquisition phase, each participant completed three practice trials to become familiar with the experimental procedures. During the acquisition phase, participants performed 60 total trials in 10 blocks of six trials each. All participants were instructed to toss the beanbag as close to the center target as possible. Participants in the SC condition were told that they could ask for feedback as often as they needed and that feedback would not be provided unless they requested it. Participants in the Y condition were told that they would receive feedback after some trials but not others. A participant in the yoked condition feedback schedule was determined by matching their schedule to the same schedule of a participant in the self-control condition. For example, if a participant in the SC condition asked for feedback on Trials 2, 3, and 6 during the first block of trials, his or her counterpart in the Y condition would receive

feedback after the same trials during the first block. Participants were tested individually and feedback referred to their own performance. When feedback was administered, it was provided verbally in the form of knowledge of results on the accuracy score for the trial and the direction in which the beanbag was located with respect to the center of the target (i.e., under, over, to the left, or to the right). For each trial, the experimenter recorded the score for the toss and whether or not KR was administered. The intertrial interval was approximately 10 seconds. At the end of acquisition all participants were handed a questionnaire regarding the amount of feedback they received (Appendix D). After approximately 24 hours, participants returned to the lab to take the retention and transfer tests. The retention test consisted of 12 trials (two blocks of six trials each) using the same task and procedures as in acquisition with the exception that KR was not provided. After a 10-minute break, the transfer test was administered. The transfer test was identical to the retention test except the distance from which the participants tossed was increased to five meters from the center of the target to assess the extent to which participants were capable of adapting to a novel but related task demand. During all three experimental phases, participants were allowed to remove the blindfold and view the empty target after the completion of each block of trials.

Data Treatment and Analysis

Accuracy scores were recorded for each trial during acquisition, retention, and transfer. Scores were determined by the assigned point value for the circle in which the beanbag landed. A toss was awarded zero points if it landed on the 10-cm radius target. The score increased by 10 points for each successive circle moving away from the target (by 10-cm increments). Tosses not landing within any of the circles were awarded a score of 100 points. For each participant in the SC condition, the trials after which feedback was received were also recorded and the

frequency of feedback requests was calculated for each trial block. For the post-experimental questionnaire, the number of responses to each question was tabulated for the SC and Y conditions.

For acquisition, accuracy scores were analyzed using a 2 (feedback condition: SC vs. Y) $\times$ 2 (activity level: A vs. S) $\times$ 10 (trial block) analysis of variance with repeated measures of the last factor. Frequency of feedback requests in the SC condition was analyzed using a 2 (activity level: A vs. S) $\times$ 10 (block) analysis of variance with repeated measures on the last factor. To examine whether or not participants in the SC condition requested feedback after “good” trials, the accuracy scores for feedback-trials and no-feedback trials were analyzed using a 2 (activity level: A vs. S) $\times$ 2 (trial type: feedback vs. no-feedback) $\times$ 2 (half of acquisition trials: first vs. second) analysis of variance with repeated measures on the last two factors. For retention and transfer, accuracy scores were analyzed using separate 2 (feedback condition: SC vs. Y) $\times$ 2 (activity level: A vs. S) $\times$ 2 (block) analyses of variance with repeated measures on the last factor. When appropriate, *F*-ratios involving repeated measures factors were reported with the Greenhouse-Geisser *df* adjustment. Partial eta-squared values (η^2) were reported to indicate effect sizes for significant results. Follow-up testing was conducted using Sidak post hoc procedures. Frequency of responses from the post-experimental interview were analyzed using a 2 (feedback condition) $\times$ 2 (trial type: “good” vs. “bad”) chi-square procedure. For all analyses, alpha was set at .05.

CHAPTER 4

Results

Table 1 shows means and standard deviations for overall performance in terms of accuracy scores under the SC-A, SC-S, Y-A, and Y-S conditions.

Acquisition

Figure 2 shows mean accuracy scores for each condition during acquisition. The SC and A conditions performed more accurately (i.e., produced lower scores) than the Y and S conditions, respectively. Both conditions showed increased accuracy across trial blocks. For the A condition, the provision of self-control did not appear to have an effect on performance whereas it appeared to facilitate performance for the S condition. These observations were supported by the significant main effects for feedback condition, $F(1, 44) = 5.05, p = .030, \eta^2 = .10$, activity level, $F(1, 44) = 62.20, p < .001, \eta^2 = .59$, and block, $F(9, 396) = 19.93, p < .001, \eta^2 = .31$. In addition, the Feedback Condition $\times$ Activity Level interaction approached significance, $F(1, 44) = 3.12, p = .085, \eta^2 = .07$. To better describe the observed pattern of effects, post hoc procedures were conducted following this interaction. The results of the follow-up tests revealed that SC-S ($M = 57.65, SD = 13.87$) condition performed more accurately than the Y-S ($M = 66.00, SD = 14.56$) condition ($p = .007$). The interactions between feedback condition and block, $F(9, 396) = .79, p = .565$, activity level and block, $F(9, 396) = .23, p = .956$, and feedback condition, activity level, and block, $F(9, 396) = 1.15, p = .335$, were not significant.

Table 1. Overall means (*M*) and standard deviations (*SD*) of accuracy scores for each level of the feedback and activity level conditions during each experimental phase. Lower scores indicate more accurate performance.

Feedback Condition	Activity Level	Experimental Phase			
			Acquisition	Retention	Transfer
SC	A	<i>M</i>	42.63	47.78	63.82
		<i>SD</i>	7.04	16.24	12.13
	S	<i>M</i>	56.64	61.67	82.99
		<i>SD</i>	9.78	12.01	11.43
Y	A	<i>M</i>	43.49	49.24	68.68
		<i>SD</i>	8.43	16.31	10.07
	S	<i>M</i>	66.00	72.78	91.11
		<i>SD</i>	6.70	14.78	5.18

SC = Self-Control; Y = Yoked; A = Active; S = Sedentary

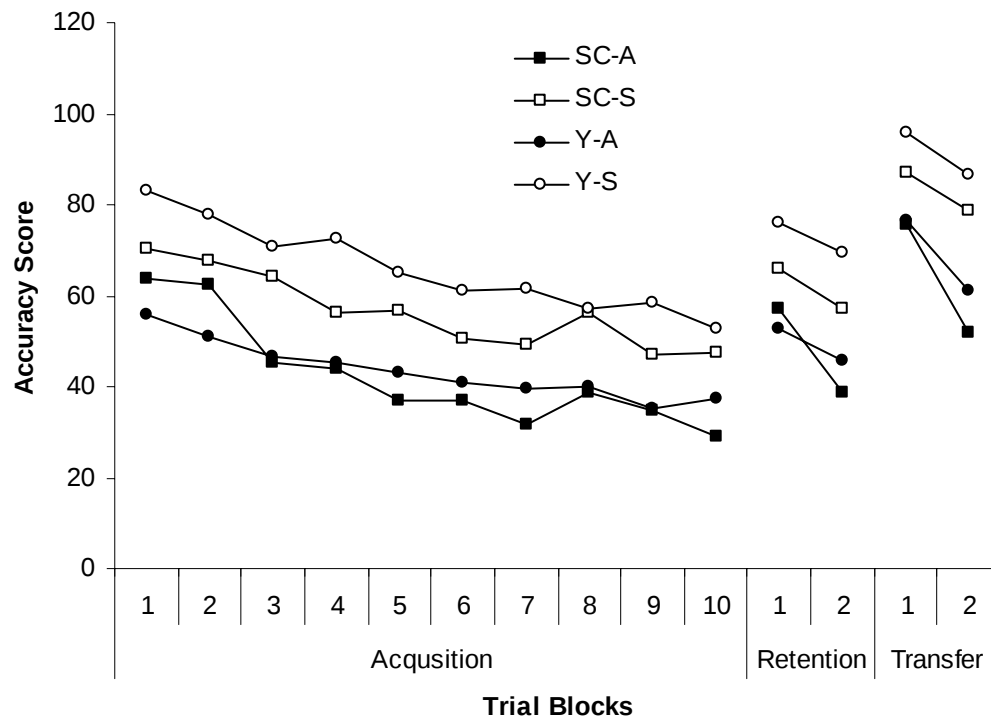


Figure 2. Mean accuracy scores for the Self-Control (SC), Yoked (Y), Active (A), and Sedentary (S) conditions during each trial block of acquisition, retention, and transfer. A lower score represents more accurate performance.

Figure 3 shows mean frequency of feedback requests for the SC condition during acquisition. The SC-A condition requested feedback more frequently than the SC-S condition during the initial blocks of acquisition. However, the frequency of feedback requests was similar by the end of acquisition. This was due to a relatively high frequency of requests by the SC-A condition during Blocks 1-5. The frequency of requests by the SC-S condition remained relatively stable throughout acquisition. These observations were supported by the significant main effects for block, $F(9, 198) = 3.31, p = .009, \eta^2 = .31$, and activity level, $F(1, 22) = 4.50, p = .036, \eta^2 = .19$, and the significant interaction between activity level and block, $F(9, 198) = 2.61, p = .031, \eta^2 = .11$. Post hoc procedures following the Activity Level $\times$ Block interaction revealed that the frequency of feedback requests was significantly higher for the SC-A condition compared to the SC-S condition during each of the first five trial blocks ($p < .048$ for all comparisons).

Figure 4 shows mean accuracy scores for feedback-trials and no-feedback-trials for the SC condition during the first and second halves of acquisition. Feedback-trials were more accurate than no-feedback-trials. The A condition was more accurate than the S condition, with both conditions improving from the first to second halves. These observations were supported by the significant main effects for trial type, $F(1, 20) = 9.31, p = .006, \eta^2 = .32$, activity level, $F(1, 20) = 11.91, p = .003, \eta^2 = .37$, and half, $F(1, 20) = 22.90, p = .001, \eta^2 = .53$. The interactions involving trial type and activity level, $F(1, 20) = 2.70, p = .116$, trial type and half, $F(1, 20) = .01, p = .914$, activity level and half, $F(1, 20) = .66, p = .427$, and trial type, activity level, and half, $F(1, 20) = .08, p = .785$, were not significant.

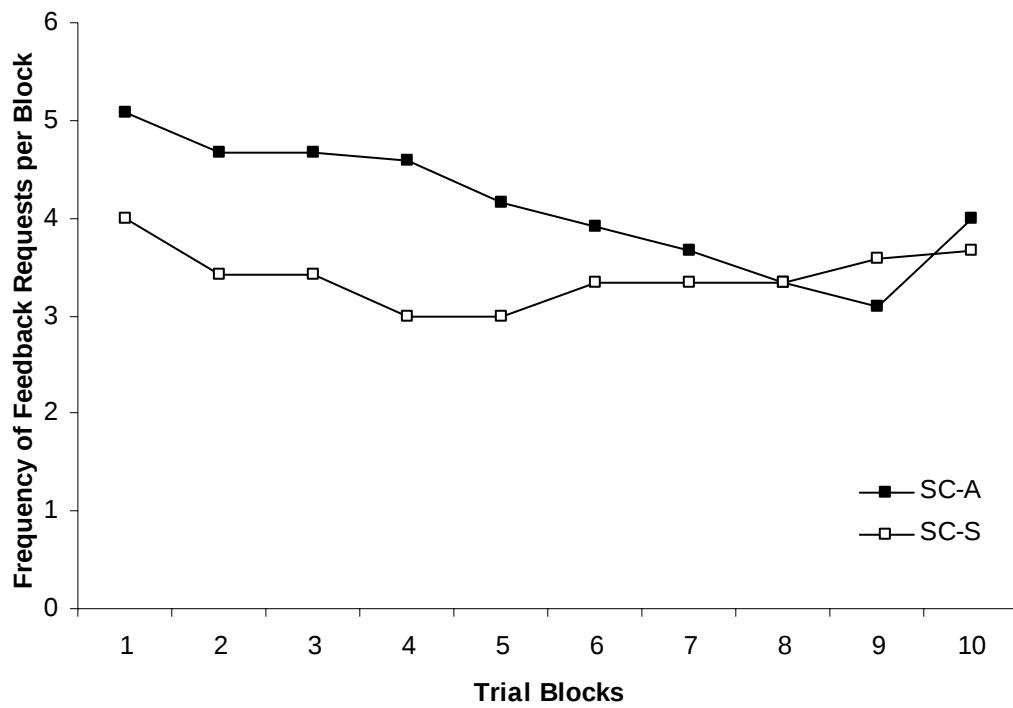


Figure 3. Mean frequency of feedback requests for the Self-Control-Active (SC-A) and Self-Control-Sedentary (SC-S) conditions during each trial block of acquisition.

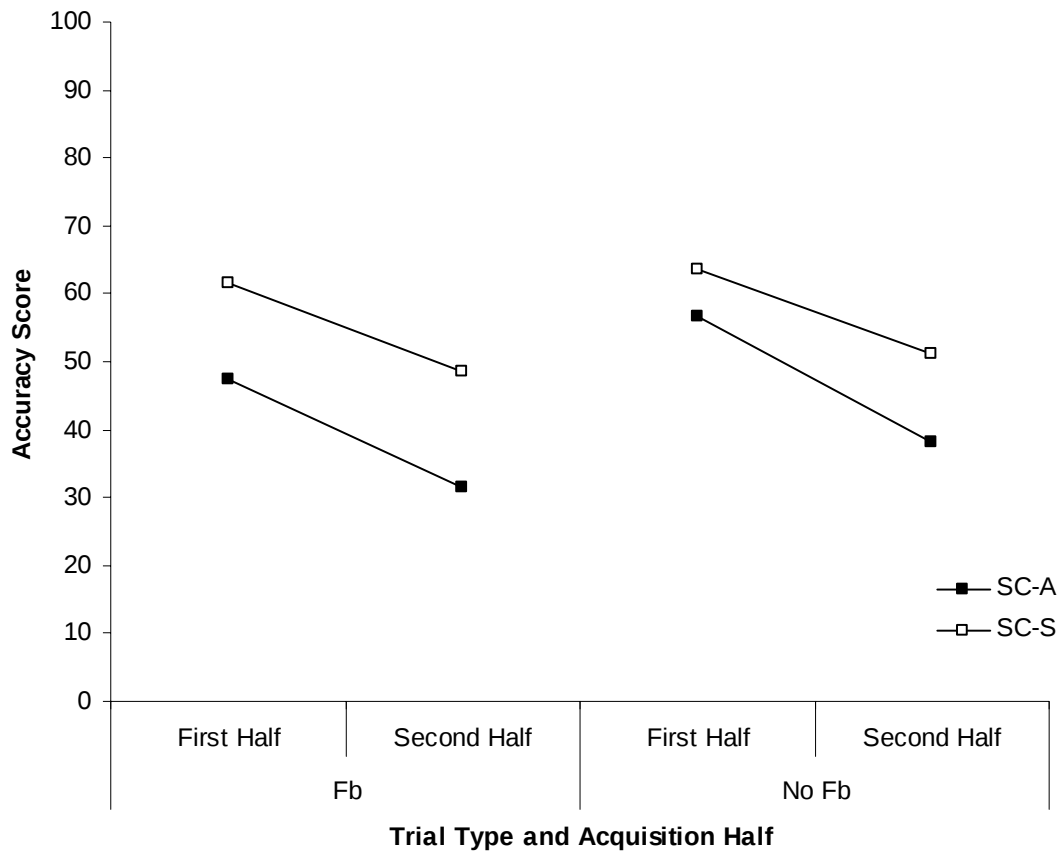


Figure 4. Mean accuracy scores for the Self-Control-Active (SC-A) and Self-Control-Sedentary (SC-S) conditions as a function of trial type (feedback—Fb vs. no-feedback—No Fb) and acquisition half. A lower score represents more accurate performance.

Retention

Figure 2 shows mean accuracy scores for each condition during retention and transfer. During retention, the SC and Y conditions both increased their accuracy scores from the first block to the second. In addition, the A condition was more accurate than the S condition. These observations were supported by the significant main effects for block, $F(1, 44) = 11.60, p < .001, \eta^2 = .21$, and activity level, $F(1, 44) = 18.84, p < .001, \eta^2 = .30$. The main effects for feedback condition, $F(1, 44) = 2.12, p = .152, \eta^2 = .03$, and the interactions between feedback condition and block, $F(1, 44) = 1.09, p = .302, \eta^2 = .02$, activity level and block, $F(1, 44) = .70, p = .407, \eta^2 = .02$, and feedback condition, activity level, and block, $F(1, 44) = .59, p = .447, \eta^2 = .02$, were not significant.

Transfer

During transfer, the SC and A conditions were more accurate than the Y and S conditions, respectively. In addition, all conditions improved across blocks. This improvement was more pronounced for the A condition than for the S condition. These observations were supported by the significant main effects for feedback condition, $F(1, 44) = 4.98, p = .031, \eta^2 = .10$, activity level, $F(1, 44) = 51.14, p < .001, \eta^2 = .54$, and block, $F(1, 44) = 60.39, p < .001, \eta^2 = .58$, and the significant interaction between activity level and block, $F(1, 44) = 8.53, p = .005, \eta^2 = .16$. Post hoc procedures following the Activity Level $\times$ Block interaction indicated that the A condition was more accurate than the S condition during both blocks ($p < .001$). The interactions between feedback condition and block, $F(1, 44) = .88, p = .355, \eta^2 = .02$, feedback condition and activity level, $F(1, 44) = .32, p = .578, \eta^2 = .01$, and feedback condition, activity level, and block, $F(1, 44) = 1.64, p = .207, \eta^2 = .04$, were not significant.

Questionnaire Results

Table 2 shows the number of responses indicating when participants either requested or would have preferred to receive feedback. For the SC condition, the majority of participants indicated that they requested feedback mostly after what they believed to be a “good” trial (14 out of 24). The majority of SC condition participants also indicated that they did not request feedback after what they believed to be a “bad” trial (19 out of 24). For the Y condition, the majority of the participants indicated that they felt they did not receive feedback when they needed it most (14 out of 24) and said that they would to have preferred feedback after what they believed to be a “good” trial (15 out of 24). Results of the chi-square analysis showed that participants in both the SC and Y conditions indicated that they either requested or would have preferred to receive feedback after “good” trials more frequently than after “bad” trials, $\chi^2_{.05(1)} = 12.35, p < .05$.

Table 2. Number of responses for the Self-Control-Active (SC-A), Self-Control-Sedentary (SC-S), Yoked-Active (Y-A), and Yoked-Sedentary (Y-S) conditions indicating when they asked for (SC) or would have preferred (Y) to receive feedback.

Feedback Condition	Activity Level	Types of Trials ¹			Total
		Good	Bad	Other	
SC	A	5	0	7	12
	S	9	0	3	12
Y	A	6	0	6	12
	S	8	2	2	12

SC = Self-Control; Y = Yoked; A = Active; S = Sedentary.

¹Indicates after which type of trial participants indicated they either asked for or would have preferred to receive feedback.

CHAPTER 5

Discussion

Discussion

The purpose of the current study was to examine the effects of a self-control manipulation on the learning of a simple movement skill by active and sedentary individuals. Four hypotheses were forwarded based on previous literature on self-control effects in motor learning (Chiviacowsky & Wulf, 2002, 2005; Wulf, 2007). The first hypothesis was that during acquisition, all conditions would demonstrate improved proficiency as indicated by increases in accuracy scores across trial blocks. The second and third hypotheses were that the self-control (SC) condition would perform with more accuracy than the yoked (Y) condition during a 24-hour retention test and subsequent transfer test, respectively. The fourth hypothesis was that performance on trials for which feedback was requested (i.e., “good” trials) would be more accurate than on trials for which no feedback was requested (i.e., “bad” trials). Exploratory issues included the comparison of active and sedentary individuals in terms of performance, learning, and number of feedback requests. Although no formal hypotheses were forwarded, it was expected that active participants would perform more proficiently than sedentary participants during all three phases of the study. It was also expected that there would be differences in the frequency of feedback requests in the self-control condition, but that the nature of these differences were not predicted.

The results provided support for Hypotheses 1 and 3. All conditions showed improvement across trial blocks during acquisition and the SC condition performed with more accuracy than the Y condition during the transfer test. Hypothesis 2 was not supported. There was no reliable difference between the SC and Y conditions during the retention test. Hypothesis

4 was supported. Feedback trials (i.e., “good” trials) were performed with more proficiency than no feedback trials (i.e., “bad” trials). These findings were consistent with previous studies of the effects of self-control manipulations on motor learning (Chiviawowsky & Wulf, 2002, 2005, 2007; Wulf, 2007; Janelle et al. 1995; 1997; Wulf, Raupach, & Pfeiffer, 2005; Wulf & Toole 1999; Wulf et al., 2001). The finding that “good” trials were more accurate than “bad” trials provided additional support for Chiviawowsky and Wulf’s claims that participants are able to evaluate their own performance and strategically use feedback to confirm success on trials perceived to be “good”. Thus, it appears that in the present study the effects of the self-control manipulation were, in part, tied to self-evaluation processes. Despite that fact that the A condition produced a greater number of “good” trials and also requested more feedback compared to the S condition, the benefits of self-control were apparent for both conditions. This indicates that the self-evaluation processes that may have been involved in the self-control effect were not influenced by the proficiency level of the learner.

Results also indicated several differences between active and sedentary conditions. The A condition was more accurate than the S condition during all three phases of the experiment. This may have been due to participants in the A condition possessing more experience with performing and learning movement skills. In addition, it was found that the A condition asked for feedback more frequently than sedentary condition during the first half of the acquisition phase. This may have been due to the fact that participants reported requesting feedback mostly after “good” trials and participants in the A condition produced more “good” trials than participants in the S condition. The lack of difference in the frequency of requests during the second half of acquisition was due to a gradual reduction in requests by the A condition. Both of these observations were consistent with Chiviawowsky and Wulf’s (2002, 2005, 2007) claims

that participants use feedback to confirm “good” performances, but also reduce their requests as practice progresses.

One interaction approached the criteria for significance and so merits some discussion. During acquisition, it was observed that the self-control manipulation appeared to facilitate performance for the sedentary individuals, but not for the active individuals. This may have been due to the proposed motivational properties of self-control manipulations. If so, it may indicate that the provision of self-control addresses a motivational deficit in sedentary individuals while adding no benefit for active individuals who may already have a high degree of intrinsic motivation to engage in learning movement skills. When interpreted from the perspective of self-determination theory (e.g., Deci & Ryan, 1985), Mullan and Markland’s (1997) illustration of the relationship between self-regulation and the stage of behavioral change for exercise raises the possibility that relatively high levels of extrinsic regulation in the beginning of typical exercise protocols might undermine the intrinsic motivation of less successful exercisers (thereby contributing to their lack of success). The acquisition results of the present study were consistent with this idea. The inferior performance of the Y-S condition relative to the other conditions may have been due to de-motivating properties of the lack of self-control afforded to this condition. In contrast, the yoking procedure did not impair the performance of active participants.

It is interesting to note that even if the yoking procedure did undermine the motivation of sedentary individuals during acquisition, this effect did not impact the results of the transfer test which revealed that the self-control manipulation enhanced learning for both A and S conditions relative to their yoked counterparts. This suggests that motivational properties of self-control may operate independently of the effects associated with self-evaluation processes. Practitioners

may want to consider that allowing sedentary participants some measure of self-control during learning could potentially enhance both motivation and learning. For example, when teaching proper form for a bench press, a personal trainer might only give initial instruction and then serve as a spotter until requested to also provide feedback. Providing the client with this measure of self-control should benefit learning, but might also motivate the client to continue to engage in behavior that is consistent with an ongoing engagement in the learning process. That is, the client given self-control might return for instruction more often than a typical client which should lead not only to learning better form but might also to more regular exercise because this exercise is an inherent part of the skill being learned.

Summary of Procedures

Participants were 48 university-age men and women recruited from the student body of The University of Tennessee. Participants were asked a series of demographic questions to determine their level activity level, age, and sex. Based on this information, participants were assigned to either an active (A) or sedentary (S) condition. Additionally, participants were also randomly assigned to either a self-control (SC) or a yoked (Y) condition to create four groups: SC-A, SC-S, Y-A, and Y-S. Participants were then provided instructions and shown how to perform the task. Acquisition consisted of 10 blocks of six trials for a total of 60 trials. The task was a blindfolded beanbag toss with the participant's non-preferred arm. Participants were instructed to toss the beanbag as accurately as possible. The SC condition participants were allowed to ask for feedback regarding their performance anytime after a trial during acquisition. The Y condition participants were informed that they would receive feedback on some trials but not others. At the beginning of each trial, the experimenter placed a beanbag in the participant's hand and provided a verbal prompt ("Ready"), after which the participant tossed the beanbag

when ready. Approximately 24 hours later, participants returned to the lab to complete a retention test consisting of two blocks of six trials with no feedback provided. After completing the retention test, participants were given a 10-minute break and then asked to complete a transfer test with no feedback provided. The transfer test was the same task just the distance from the participant and the target was moved back from three meters to five meters to make the novel task harder.

Accuracy scores were recorded for each trial. Scores were awarded based on the area in which the beanbag landed. Zero points were awarded for hitting the 10-cm radius target and scores increased by 10 points for each additional 10 cm away from the target. Trials on which feedback was requested were also recorded.

Summary of Findings

The experiment revealed several significant results for accuracy scores and frequency of feedback requests:

1. Accuracy scores during acquisition:
 - a. Feedback condition, $F(1, 44) = 5.05, p = .030, \eta^2 = .10$.
 - b. Activity level, $F(1, 44) = 62.20, p < .001, \eta^2 = .59$.
 - c. Trial block, $F(9, 396) = 19.93, p < .001, \eta^2 = .31$.
 - d. Trial type (feedback vs. no-feedback), $F(1, 20) = 9.31, p = .006, \eta^2 = .32$.
2. Frequency of feedback requests in the self-control condition during acquisition:
 - a. Activity level, $F(1, 22) = 4.50, p = .036, \eta^2 = .19$.
 - b. Trial Block, $F(9, 198) = 3.31, p = .009, \eta^2 = .31$.
 - c. Activity Level x Trial Block interaction, $F(9, 198) = 2.61, p = .031, \eta^2 = .11$.

- i. Activity level within self-control condition for first five trial blocks ($p < .048$ for all comparisons).
- 3. Accuracy scores during retention:
 - a. Activity level, $F(1, 44) = 18.84, p < .001, \eta^2 = .30$.
 - b. Trial block, $F(1, 44) = 11.60, p < .001, \eta^2 = .21$.
- 4. Accuracy scores during transfer:
 - a. Feedback condition, $F(1, 44) = 4.98, p = .031, \eta^2 = .10$.
 - b. Activity level, $F(1, 44) = 51.14, p < .001, \eta^2 = .54$.
 - c. Trial block, $F(1, 44) = 60.39, p < .001, \eta^2 = .58$.
 - d. Activity Level x Trial Block interaction, $F(1, 44) = 8.53, p = .005, \eta^2 = .16$.
 - i. Activity level during both blocks ($p < .001$ for both comparisons).
- 5. Questionnaire responses indicating requests or preference for feedback after different trial types (good vs. bad):
 - a. Effect of trial type, $\chi^2_{.05(1)} = 12.35, p < .05$.

Conclusions

The findings of the present study led to the following conclusions:

1. The provision of self-control of feedback facilitated transfer of motor skills when compared to a yoked condition.
2. When provided self-control, active participants asked for feedback more frequently than sedentary participants.
3. When provided self-control, both active and sedentary participants reported asking for feedback primarily after good trials.

Limitations

1. All data was collected in the motor behavior lab. The presence of a relatively low ceiling may have caused some participants to feel restricted in their actions related to projecting the beanbag.
2. The IPAQ was a potential limitation because it only takes into account activity during the previous week and, therefore, does not distinguish between long-term and short-term engagement in physical activity.

Recommendations

The following are recommendations for further study that result from findings of the current study.

1. Further study is needed to compare active and sedentary individuals in terms of motor learning, especially as they may relate to self-regulation and self-control manipulations. The results of the present study suggested possible interactions between activity level and the self-control manipulation, which need further study for verification.

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APPENDICES

APPENDIX A INFORMED CONSENT FORM

Self-Controlled Feedback and Activity Level in Learning a Simple Movement Skill

You are invited to participate in a research study. The purpose of this study is to investigate the effect of self-controlled (learner controlled) feedback on learning a simple motor skill. As a participant in this study you will be performing one simple motor skill a number of times. This skill involves tossing a bean bag a short distance to a target placed on the floor while blindfolded. There are no foreseeable risks associated with participation.

At the beginning of the experimental session, you will be given written instructions, which the experimenter will also read aloud. During these instructions, you may ask questions whenever you like. Following the instructions, you will complete a questionnaire about your activity levels. Then, the experimenter will demonstrate the task to you. You will have the opportunity to practice the task a few times before data collection begins. You will stand in front of the target at a distance marked out on the ground by the experimenter. Today, your goal is to learn to toss the beanbag with your non-preferred hand so that it lands as close to the center circle on the target as possible. Your proficiency on this task will be tested tomorrow.

Each trial will begin with the experimenter handing you the beanbag and asking you to toss it to the target. Depending upon the condition to which you are assigned, you will either be able request feedback after each attempt or it will be given to you according to a pre-determined schedule. The experimenter will record your performance scores before you begin the next trial. Your participation will require approximately 90-120 minutes. You will be asked to complete a practice session today and return to the laboratory tomorrow for testing. During practice, you will complete 10 six-trial blocks. At the end of the 60 tosses you will be asked to fill out a questionnaire regarding the feedback you received or requested.

The information in the study records will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports, which could link you to the study.

If you have questions at anytime about the study or the procedures, you may contact the researcher, Timothy V. Nguyen or his faculty advisor, Dr. Jeffrey T. Fairbrother, at 1914 Andy Holt Avenue, 322 HPER, Knoxville, TN 37996, or (865) 974-3616. If you have any questions about your rights as a participant, contact the Research Compliance Services section of the Office of Research at (865) 974-3466.

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed, your data will be returned or destroyed.

I have read the above information and agree to participate in this study. I have received a copy of this form.

Participant's Name (Print) _____

Participant's Signature _____

Date _____

APPENDIX B INSTRUCTIONS

Self-Controlled Feedback and Activity Level in Learning a Simple Movement Skill

The first part of this study requires you fill out the International Physical Activity Questionnaire (IPAQ). The IPAQ consists of seven (7) questions that will help us assess the kinds of physical activities that you do as part of your everyday life. Answer the questions to the best of your ability. I will read the questions out loud to you and give you a copy to read along. The total time to fill out the questionnaire is approximately two (2) minutes.

Today you will be performing a simple movement skill. For this study you will be performing a task known as the beanbag toss. The task will require you to use your non-preferred hand to toss the beanbag while being blindfolded. This means if you are right handed you will perform the task with your left hand and vice-versa. The purpose of the blindfold is to assess your ability to learn this task. You will be able to see the target before you begin each block of 10 trials. This means that you will see the target, then put on the blindfold and complete ten 10 beanbag tosses before you can see the target again. You will be given an opportunity to practice this task before you will be tested today. I will demonstrate the task to you before you begin and give you an opportunity to ask questions.

You will have to complete 6 blocks of 10 trials for a total of 60 trials today. Tomorrow you will have to return to the lab (approximately 24 hrs later) to complete 2 blocks of 6 trials for a total of 12 tosses. The total time for the first day is approximately 45-65 minutes, while the total time for the second day is approximately 20-35 minutes.

Depending on the experimental condition that you are assigned to you will be able to request feedback to help you learn the task. You will be able to request as much feedback as necessary for you to learn the task, however you will be tested on the second day with no feedback being provided to assess your learning ability. At the end of the first day you will be given another questionnaire regarding the type of feedback that was provided to you. You are to answer the questionnaire to the best of your ability. I will read the questionnaire out loud to you and provide you with a copy to read along. The feedback provided will be a performance score or the zone you land in, and if you are to the right, left, over or under the target. The target will be the center of the yellow mat placed on the floor. If you hit the target you will be awarded zero (0) points for zero error and each following circle outside the target will increase by 10 points. If you toss the beanbag outside of the circles you will be receive 100 error points.

Your goal for this study is to be as accurate as you possible can.

At this time do you have any questions?

APPENDIX C

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

☐

No vigorous physical activities



Skip to question 3

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐

Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

☐

No moderate physical activities



Skip to question 5

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → *Skip to question 7*

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

APPENDIX D

Questions for the self-control and yoked participants after the practice phase.

Self-control condition

1. When/why did you ask for feedback?
 - a. ☐ mostly after you thought you had a good trial
 - b. ☐ mostly after you thought you had a bad trial
 - c. ☐ after good or bad trials equally
 - d. ☐ randomly
 - e. ☐ did you have any other reasons in deciding to request feedback?

2. When did you NOT ask for feedback?
 - a. ☐ after good trials
 - b. ☐ after bad trials
 - c. ☐ did you have any other reasons in deciding to NOT request feedback?

Yoked condition

1. Do you feel you received KR when you needed it most?
 - a. ☐ Yes Proceed to Question 2
 - b. ☐ No Proceed to Question 3
2. If you feel you received KR when you needed it most please explain when (or what trials) did you feel you received KR the most?
 - a. ☐ mostly after you thought you had a good trial
 - b. ☐ mostly after you thought you had a bad trial
 - c. ☐ after good or bad trials equally
 - d. ☐ randomly
 - e. ☐ did you have any other reasons in deciding to request feedback?

3. If the answer was “No,” when would you have preferred to receive feedback:
 - a. ☐ after good trials
 - b. ☐ after bad trials
 - c. ☐ doesn’t matter
 - d. ☐ if none of the previous apply, please explain when you would have preferred to receive feedback

*Adapted from Chiviackowsky and Wulf, 2002.

Vita

Timothy Van Nguyen was born in Columbus, OH on January 8, 1983. He was raised in Columbus, OH and went to Columbus Public Schools for grade school and middle school. He graduated from Groveport Madison Sr. High School in 2001. From there he went to the University of Tennessee, Knoxville and received a B.A. in psychology in 2006. Timothy is currently pursuing his master's degree in sports studies, majoring in sports psychology at the University of Tennessee, Knoxville, TN.