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Should feedback confirm success, correct errors, or both? An empirical test of the sandwich approach to delivering feedback

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I am submitting herewith a dissertation written by Kevin Allan Becker entitled "Should feedback confirm success, correct errors, or both? An empirical test of the sandwich approach to delivering feedback." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Kinesiology and Sport Studies.

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ABSTRACT

In motor learning, feedback has long been viewed as a mechanism for correcting errors present in a skill. Recent research has suggested that feedback that confirms the success of a movement can also be valuable for learning (Chiviacowsky & Wulf, 2007). The purpose of the present study was to test the relative merits of knowledge of performance feedback that confirms success (CONF), corrects errors (CORR), or does both through the method commonly referred to as the sandwich approach (SAND). Participants (36), were randomly assigned to one of the three feedback groups, and practiced a soccer throw-in task. The acquisition phase consisted of 30 trials with feedback after each trial about the most critical error (CORR), the most critical component of form performed correctly (CONF), or a combination of the two (SAND). Approximately 24 hrs after the conclusion of acquisition, participants completed a retention test, and two transfer tests. Participants completed self-efficacy assessments prior to the start of each experimental phase, and then completed a post-experiment questionnaire after the conclusion of the study. Results revealed that the CORR group and the SAND group received higher form scores than the CONF group across acquisition, retention, and both transfer phases ($p < .05$). The SAND and CORR groups, however, did not differ with regard to form. No differences between groups emerged for self-efficacy, but the post-experiment questionnaire revealed the SAND and CORR groups found the feedback to be more useful than the CONF group ($p < .05$). The results of this study suggest that for learning complex tasks, feedback including corrections leads to better form than feedback only confirming success. There was, however, no documented advantage to receiving both corrective and confirmatory feedback as opposed to corrective feedback only. The findings here contrast with recent studies suggesting a benefit of feedback

after “good” trials, and support the notion that when learning complex tasks corrective information is needed for learning.

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CHAPTER 1

Introduction

When learning motor skills, people often use feedback from a variety of sources. In motor learning research, feedback is divided into two broad categories. Intrinsic or inherent feedback is information about an attempt that is readily available to the performer as a result of completing the task. For example, seeing a basketball bounce off the rim is inherent feedback for a set shot. Extrinsic or augmented feedback, in contrast, is information that must be provided by external sources (Magill, 2010). An example is a coach telling a novice basketball player that her shooting form was correct. Motor skills can certainly be learned in the absence of augmented feedback, but it is thought to facilitate and expedite the learning of complex skills. Augmented feedback is assumed to have at least two roles in motor learning (e.g., Schmidt & Lee, 2011; Magill, 2010). First, it informs learners how actual and desired performances differ. The *informational role* of augmented feedback has been the most studied and has therefore become a central part of most discussions of how feedback affects learning. Second, feedback is also thought to fulfill a *motivational role* by providing information about progress that can energize learners to devote greater effort during practice (Schmidt & Wrisberg, 2008). Although the motivational role of augmented feedback in motor learning has received little attention, recent research has examined the effects of feedback on related affective variables such as self-efficacy and perceived competence. The primary focus of the current study was on the informational role of augmented feedback, but self-efficacy was also examined as a secondary variable that could help explain or qualify the primary results.

The informational role of augmented feedback has traditionally been conceptualized as information used by the learner to correct errors. Early research focused mainly on of the effects of augmented feedback about the outcome of movements, known as *knowledge of results* (KR), on learning simple laboratory tasks (see Salmoni, Schmidt, & Walter, 1984 for a review). For example, KR for a lever positioning task would convey information about how far the final lever position deviated from the criterion position. The error information typically presented in KR has been shown to benefit immediate performance and long-term learning. High administration frequencies during practice (e.g., after 100% of trials), however, have been shown to degrade learning relative to conditions that received KR less often (e.g., Lee, White, & Carnahan, 1990). It has been presumed that frequent KR can produce dependence and thus degrade subsequent performance during no-KR tests to assess learning. These observations were a critical piece in the formulation of the *guidance hypothesis*, which states that feedback guides the learner to the correct response (via information) and that such guidance can sometimes produce dependence (Salmoni et al., 1984).

The guidance hypothesis has been supported by findings that *reduced relative feedback frequencies* facilitate learning compared to higher frequency conditions (e.g., Winstein & Schmidt, 1990). Interest in the informational role of KR has largely been consistent with the guidance hypothesis assumption that feedback helps learners correct their errors. More recent research, however, has prompted interest in the potential role of feedback in confirming the success of a movement. This notion emerged from an examination of self-controlled feedback effects, which reported that participants indicated a preference for receiving feedback mostly after so-called "good" trials (Chiviacowsky & Wulf, 2002). Indeed, approximately two-thirds of the participants in the self-control condition indicated that they asked for feedback mostly after good trials and did *no*t request it after bad trials. This finding contradicted the traditional view that the information in feedback primarily serves to correct errors. To determine if learners' preferences for feedback after good trials facilitated learning, Chiviacowsky and Wulf (2007) examined conditions that only received feedback after either good or bad trials. After each set of six acquisition trials, participants in one group received feedback about their best three (good) trials while participants in the other group received feedback about their worst three (bad) trials. Results indicated that feedback after good trials facilitated learning. The good-KR group threw more accurately during retention than the bad-KR group.

Interestingly, earlier research on the effects of *bandwidth feedback* can also be interpreted as including information that confirmed the success of a trial. Bandwidth feedback is a method of feedback delivery designed to reduce the frequency of feedback by providing feedback only after trials with relatively large errors. For example, Sherwood (1988) delivered feedback for a timed lever positioning task only when timing error exceeded a set percentage of the 200 ms goal. Results showed a benefit of 10% bandwidth feedback compared to a condition that received feedback after every trial. Although this benefit has typically been attributed to reduced frequency, it is also possible that it stemmed in part from the fact that participants received both corrective KR on trials with errors outside the bandwidth and confirmation of success through the absence of feedback on trials within the bandwidth. Bandwidth feedback does not actually reduce the frequency of feedback, per se. It creates a situation in which participants receive explicit feedback about errors on some trials and implicit confirmation about success on the other trials. Thus, the benefits of bandwidth feedback compared to conditions receiving corrective feedback after every trial could be due to the effects of implicit confirmation of success after the good trials (within the bandwidth) or the combination of corrective and confirmatory feedback.

Another line of research relevant to the consideration of the roles of corrective and confirmatory feedback has examined the effects of normative feedback on motor learning. One study compared conditions that received corrective feedback either alone or in combination with false positive or negative normative feedback. The false normative feedback conditions were told that their performance was either 20% above (positive) or 20% below (negative) average. The positive false normative feedback group outperformed the other two groups during retention testing, suggesting that motor learning was facilitated by the addition of feedback indicating general success. As with bandwidth feedback, the benefits associated with the positive false normative feedback may have been due to the confirmation of success or its combination with the corrective feedback. These interpretations of the bandwidth and false normative feedback research reveal a need to better understand the combined and independent effects of corrective and confirmatory feedback. The potential benefit of combining these two types of feedback is consistent with the so-called sandwich approach advocated in the sport psychology and coaching literature (e.g., Weinberg & Gould, 2011). Although this approach is often recommended, there are no direct examinations of its efficacy compared to other feedback approaches.

Another important issue in the consideration of confirmatory and corrective feedback is the fact that most previous research has been limited to the use relatively simple tasks that lend themselves to the use of KR as the primary form of augmented feedback. Many motor skills, especially those seen in applied settings such as sport, are far more complex and require a greater emphasis on the quality of the movement rather than just the outcome. Accordingly, knowledge of performance (KP), which is augmented feedback focused on movement form, is often favored by instructors (Fishman & Tobey, 1978). When delivering KP about a complex motor skill, there are typically several aspects of the movement that can be emphasized. For example, KP feedback for a basketball set shot could relate to foot position, grip, or the follow-through motion. It is often the case that some features will be performed correctly while others will not, which underscores the importance of determining whether feedback should focus on correction, confirmation, or both. The use of KP for complex tasks highlights the challenges inherent in labelling a trial as good or bad, and thus in determining if learners actually have preferences for feedback following each type of trial. Indeed, examinations of self-controlled feedback preferences in studies that have used complex tasks and provided KP have revealed that participants used feedback about as often after good trials as after bad trials (Aiken, Fairbrother, & Post, 2012; Holmberg, 2013; Laughlin, 2012). These findings are inconsistent with the notion that learners prefer feedback after good trials and the ensuing interpretation that confirmation of success might be a critical feature of the role of augmented feedback in motor learning (Chiviacowsky & Wulf, 2002, 2007).

If confirmatory feedback does facilitate learning, it would presumably operate through an affective variable such as self-efficacy. Self-efficacy refers to the belief in one's ability to perform specific behaviors as opposed to a general assessment of ability (Bandura, 1997). Feedback after good trials has been shown to enhance both self-efficacy (Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki, 2012) and general self-confidence (Badami, VaezMousavi, Wulf, & Namazizadeh, 2012). Because these studies employed relatively simple tasks and KR, there is a need to determine if their findings extend to more complex motor learning situations representative of real-world learning situations. The purpose of the present study was to determine the combined and independent effects of corrective and confirmatory KP on the learning of a complex motor skill. KP was used because it allowed a broad representation of task performance consistent with learning complex skills. A secondary purpose was to determine if differences in self-efficacy emerged as a result of the different feedback interventions and to determine if such differences would qualify the performance results. Based on previous research, there are a number of possible outcomes for this study. If the benefit of feedback after good trials (Chiviacowsky & Wulf, 2007) generalizes to complex tasks and the use of KP, then it would be expected that confirmatory feedback will facilitate learning more so than corrective feedback. If increased task complexity makes both corrective and confirmatory feedback useful (as indicated in Aiken et al., 2012), the combined effects would be expected to facilitate learning compared to the independent effects of either form of feedback. In terms of self-efficacy, previous research suggests that confirmatory feedback alone or in combination with corrective feedback will raise self-efficacy scores more than corrective feedback.

Statement of the Problem

Previous research has suggested possible independent effects of confirmatory and corrective feedback on motor learning. Current understanding is limited, however, by the lack of direct examinations and the use of simple laboratory tasks and outcome focused feedback. There is a need, therefore to examine the combined and independent effects of corrective and confirmatory KP on the learning of a complex motor skill.

Purpose of Study

The purpose of the present study was to determine the combined and independent effects of corrective and confirmatory KP on the learning of a complex motor skill. A secondary purpose was to determine if differences in self-efficacy emerged as a result of the different feedback interventions and to determine if such differences qualified performance findings.

Hypotheses

- It was hypothesized that participants receiving feedback with the sandwich approach would have higher form scores than those receiving corrective feedback and those receiving confirmatory feedback throughout all phases of the experiment.

- It was hypothesized that participants receiving corrective feedback would have higher form scores than those receiving confirmatory feedback throughout all phases of the experiment.
- It was hypothesized that participants receiving feedback with the sandwich approach, and those receiving confirmatory feedback would have higher self-efficacy than those receiving corrective feedback on assessments prior to each of the testing phases.
- No hypotheses regarding accuracy scores were made as the feedback being manipulated was not knowledge of results.

Assumptions

- All participants performed the task consistent with instructions to the best of their capabilities.
- All participants were truthful regarding their previous experience with the soccer throw-in task.
- All participants complied with the instruction to not practice the task outside of the experiment between the acquisition and retention/transfer phases.

Delimitations

- Participants were 21 female and 15 male undergraduate and graduate students at the University of Tennessee
- Participants did not play organized soccer at the high school level or higher
- Participation in the study was voluntary
- The study was conducted in a laboratory setting

Limitations

- The experimenter was not blind to experimental condition
- Participants' responses on self-efficacy were self-report
- While applied in nature, the task did not take place in an applied setting

Definition of Terms

Acquisition. The initial phase of a motor learning study during which the participant practices the motor task (Janelle, Kim, & Singer, 1995).

Augmented feedback. Information about a movement that is provided to the learner from an outside source (Fairbrother, 2010).

Bandwidth Feedback. Feedback that is given only when gross motor errors occur (Sherwood, 1988).

Corrective Feedback. Feedback about a movement that diagnoses an error.

Confirmatory Feedback. Feedback about a movement that reinforces a correct pattern.

Extrinsic Feedback. See Augmented Feedback.

Feedback. Performance-related information that a learner receives during and/or after skill execution (Magill, 2010).

Guidance Hypothesis. Viewpoint that feedback guides the learner toward the desired movement, and can also lead to dependence when always present (Salmoni, Schmidt, & Walter, 1984).

Imaginal experiences. Experiences occurring through the use of mental imagery (Feltz, Short, & Sullivan, 2008).

Informational function of feedback. Viewpoint that feedback facilitates learning through providing a comparison between the movement produced and the desired movement (Schmidt & Wrisberg, 2008).

Intrinsic/Inherent Feedback. Information available to the individual through sensory channels during, or resulting from the execution of the movement (Schmidt & Lee, 2011).

Knowledge of performance (KP). Augmented feedback about the nature of a movement (Fairbrother, 2010).

Knowledge of results (KR). Augmented feedback about the outcome of a movement (Fairbrother, 2010).

Learning effects. Effect of an intervention on relatively permanent changes in the performance of a motor skill.

Motivational function of feedback. Viewpoint that feedback influences learning through energizing and directing a person's behavior (Schmidt & Wrisberg, 2008)

Motor domain. Area of psychological research focusing on the function of motor skills.

Motor Performance. The process of producing a motor skill.

Motor Learning. A set of processes associated with practice or experience leading to relatively permanent changes in the capability for movement. (Schmidt & Lee, 2011).

No KR retention test. A delayed test of the motor skill in which KR present in the acquisition period has been removed, but the task performed is the same (Schmidt & Lee, 2011).

No KR transfer test. A delayed test of the motor skill in which KR present in the acquisition period has been removed, and some change has been made to the task (Schmidt & Lee, 2011).

Normative feedback. Feedback indicating how a participants' performance compares to the performance of others (Wulf, Chiviacowsky, & Lewthwaite, 2010).

Performance effects. Immediate changes in behavior that tend to be temporary and disappear in the absence of the intervention (e.g., feedback).

Redundant Knowledge of Results. Augmented KR feedback that duplicates readily available intrinsic feedback.

Relative feedback frequency. Percentage of performance attempts for which feedback is given (Schmidt & Wrisberg, 2008).

Retention. A test of a practiced skill that a learner performs to assess learning following an interval of time after practice has ceased (Magill, 2010).

Self-control feedback. Giving a learner some degree of control over the learning environment (Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997).

Self-efficacy. A form of self-confidence that refers to beliefs about one's capability to plan and execute the behaviors needed for successful production of the outcomes (Bandura, 1997).

Self-efficacy level. The highest degree of challenge a person perceives themselves as able to complete (Bandura, 1977).

Self-efficacy strength. How certain a person is that he/she can successfully perform the task at each level (Bandura, 1977).

Social Comparative Feedback. See Normative Feedback.

Soccer throw-in. A soccer skill requiring a player to throw the ball in with two hands, overhead, while keeping both feet on the ground outside of the field of play.

Transfer. A test in which a person performs a skill that is similar yet different from the skill that he or she has practiced (Magill, 2010).

Yoked. Matching of a participant to the same protocol experienced by another participant.

CHAPTER 2

Review of Literature

The purpose of this chapter is to provide a review of the existing research in the areas of feedback and self-efficacy as they relate to motor learning. It will consider the functions of feedback in motor learning, and how feedback has been studied in the existing literature. Topics such as different types of feedback, scheduling of feedback, and methods for determining when to give feedback will be explored. These topics provide relevant background information for understanding how corrective and confirmatory feedback might affect motor learning. For self-efficacy, the theoretical background from both general psychology and sport psychology are presented and discussed with respect to how feedback might influence self-efficacy and how self-efficacy in turn might influence learning.

Feedback and Motor Learning

Feedback about a performance can come from a variety of sources. In some cases, our senses provide us with *intrinsic or inherent feedback* that is readily available as a function of completing a task. For example, a person throwing darts can see where the dart lands on the board. This type of feedback can help guide future performances and facilitate learning. With complex skills, learners often need additional feedback beyond what their senses directly detect. This type of feedback is typically referred to as extrinsic or augmented feedback (Schmidt & Lee, 2011). Traditionally, augmented feedback has been recognized as one of the most important variables for motor learning aside from practice itself.

Augmented feedback has been assumed to have a number of characteristics that influence motor learning. Two of the most commonly cited are its roles in providing information about a performance and motivating learners (e.g., Schmidt & Lee, 2011; Magill, 2010). Augmented feedback provides an external source of information indicating to learners how an actual performance compared to intended performance. The information conveyed might focus on a movement outcome (e.g., the speed of a tennis serve) or on technique (e.g., shooting form for a basketball set shot). The information function has typically been associated with efforts to identify and correct errors (e.g., Schmidt & Wrisberg, 2008). This perspective has been largely influenced by the common practice in motor learning research of using procedures that either eliminate or restrict intrinsic feedback to facilitate examinations of augmented feedback manipulations. Presumably, such conditions disrupt the normal relationship between movements and resulting sensory consequences. For example, a person asked to move a lever to a specific position would receive relevant sensory information from vision, proprioception, and kinesthesis. Removing vision would create an information gap because the task would not normally be controlled using only the latter two senses. Augmented feedback about the final position of the lever would then provide the information to fill this gap. The performer would learn through a series of missteps that are corrected in turn using the information in the augmented feedback (e.g., “too far” or “too short”). The other commonly cited function of augmented feedback is to motivate learners as they practice a task. According to Schmidt and Lee (2011), augmented feedback can make the task more interesting, keep learners alert, and encourage them to set higher performance goals. Early considerations of both the information and motivation functions of augmented feedback were centered on their potential transient or temporary effects on motor performance (see Salmoni, Schmidt, & Walter, 1984). Specifically, it was thought that performance would deteriorate when the guidance and energizing effects were removed with the withdrawal of augmented feedback. Subsequent research has demonstrated that augmented feedback exerts both temporary *performance effects* and relatively permanent *learning effects*.

Currently, the notion that motivation to apply greater effort during practice indirectly enhances learning is at least implicit in many discussions of augmented feedback's effects on motor learning (e.g., Schmidt & Wrisberg, 2008).

Augmented feedback can be classified in a variety of ways. The most common distinction is between knowledge of results (KR) and knowledge of performance (KP). KR is information about the outcome of the movement, while KP is information about the characteristics of the movement (Magill, 2010). In the motor domain, the vast majority of feedback research has focused on the effects of KR. A likely reason for this tendency is the experimental control afforded by studies measuring the effects of KR. These studies typically use a simple one-dimensional task that provides little or no intrinsic feedback. As a result, it is relatively straightforward to isolate the effects of KR on learning. A drawback to this approach is the limited ecological validity. In applied settings such as sport and physical education, KP is the more common form of feedback. Fishman and Tobey (1978) monitored the instruction of physical education teachers and found that 94% of augmented feedback was KP and only 6% was KR. For real-world tasks in applied settings, KR is often redundant with intrinsic information limiting its value, while KP can provide additional support for learning. It has often been assumed that KR and KP function in a similar manner and that findings from the KR literature should also apply to the use of KP (Schmidt & Lee, 2011). Although there is no direct evidence to contradict this assumption, more research on the role of KP in learning is needed to determine its validity.

Early research (for a review, see Adams, 1971) focused on the scheduling of feedback seemed to indicate that it was most effective when given 100% of the time. Subsequent research, however, revealed the important distinction between KR's temporary performance effects and its longer lasting influence on learning. A comprehensive review of the literature (Salmoni et al., 1984) showed that although feedback on 100% of trials facilitated immediate performance, it was also associated with degraded performance on delayed no-KR retention tests. In contrast, lower relative feedback frequencies were associated with depressed immediate performance or enhanced learning (e.g., Annett, 1959; Ho & Shea, 1978. Salmoni et al. emphasized the importance of no-KR transfer tests to allow conclusions that learning occurred. They also proposed the *guidance hypothesis* to explain the role of feedback in motor performance and learning. The guidance hypothesis states that feedback guides future performances by informing learners of errors in execution. However, when feedback is provided too frequently, learners can develop dependency which undermines long term learning. Subsequent research has been careful to distinguish between the immediate performance effects of feedback and its influence on learning as inferred from no-KR transfer tests.

The guidance hypothesis has been tested several times, most often in examinations of the effect of feedback frequency on motor performance and learning. Work in this area informs the present study because early feedback research focused almost exclusively on correcting errors. To understand how corrective and confirmatory feedback influence learning, it is worth considering research examining the potential benefit of restricting error correction information. Lee, White, and Carnahan (1990, Experiment 3) examined the effects of reduced frequency KR on immediate performance and delayed retention. The experiment used a simple task requiring the participant to sequentially tap two targets in a criterion time of 500ms. Auditory KR was administered after every trial (100%) or every other trial (50%). The results provided support for the guidance hypothesis by showing that the 50% KR facilitated retention. Other studies have also shown that reduced KR frequency can facilitate learning (e.g., Sparrow & Summers, 1992; Vander Linden, Cauraugh, & Greene, 1993).

A smaller number of studies have examined reduced frequency KP effects. Weeks and Kordus (1998) examined the effects of a 33% relative KP frequency condition on the performance and learning of a soccer throw-in compared to a 100% condition. The KP statements focused on one of eight different movement form elements (similar to the current study). During all three experimental phases (acquisition, retention, and transfer), the 33% group achieved higher form scores than the 100% group. In contrast to previous studies, the 33% group did not suffer a performance decrement during acquisition.

In light of the findings that reduced feedback can facilitate learning, researchers have examined different ways to schedule feedback other than simply reducing the overall frequency during practice. Winstein and Schmidt (1990, Experiment 2) examined the effects of a faded feedback schedule based on the notion that frequent feedback early in practice might guide the learner while progressively decreasing the frequency would minimize dependency. The faded schedule initially provided KR after every trial and progressively diminished administration frequency as practice progressed (resulting in a 50% overall frequency). Although no group differences emerged during acquisition, the faded feedback group produced significantly lower error scores during delayed retention.

Another approach to scheduling feedback has been termed the *bandwidth* method (Sherwood, 1988). This approach provides feedback only when errors exceed an acceptable range of deviation from the target (i.e., bandwidth). When participants' scores are within the accepted bandwidth, they do not receive feedback. In most cases, participants are told that no feedback indicates a successful performance. Sherwood (1988) examined the effects of different size bandwidths. Participants were assigned to 5% or 10% bandwidth groups or a 100% KR control group. The 10% group showed less variability than the other groups during transfer indicating that bandwidth KR can facilitate learning.

The learning benefit of bandwidth feedback has since been replicated multiple times for a variety of tasks (Graydon, Paine, Ellis, & Threadgold, 1997; Shewokis, Kennedy, & Marsh, 2000; and Ugrinowitsch, Ugrinowistch, Benda, & Tertuliano, 2010). Early research on bandwidth feedback used simple tasks. One exception was a study that used golf chipping as a task (Smith, Taylor, & Withers, 1997). In addition to KR regarding accuracy, the feedback also included transitional statements about the process of correctly chipping a golf ball. This study is of particular interest as it is much more consistent with what happens in many applied settings. Results indicated that the 10% bandwidth group was less variable than the 100% control group during retention. This finding was consistent with Sherwood (1988), showing that bandwidth feedback effects generalized to a complex task.

The learning benefit of bandwidth feedback has traditionally been attributed to the reduced frequency associated with its schedule. To test this notion, Lee and Carnahan (1990) compared 5% and 10% bandwidth groups with two control groups yoked to receive feedback on the same schedule as the bandwidth. The results revealed that the two bandwidth groups performed with less variability than the yoked groups during retention, indicating that there is an additional advantage to bandwidth feedback beyond the reduced frequency effect. Feedback research has traditionally focused on the effects of providing information to correct errors. In a bandwidth feedback protocol, however, trials falling within the bandwidth also offer implicit feedback that the performance was acceptable. The possibility that this type of confirmation might also influence learning has received little attention in the motor learning literature. Lee and

Carnahan (1990) speculated that confirmation of a correct response could encourage learners to stabilize their movement pattern, just as corrective feedback encourages them to change it. A bandwidth feedback protocol offers a more individualized feedback schedule because it is based on the learner's actual performance. Faded feedback schedules are thought to be effective because they offer guidance during early learning and reduce the risk of dependency as proficiency increases. . Interestingly, bandwidth feedback tends to create a faded schedule but does so based on the individual's performance.

An approach that offers an even more individualized approach is allowing the learner to control when they receive feedback. Self-controlled feedback (i.e., learner controlled feedback) is a relatively new line of feedback research in the motor learning literature. In an early study, Janelle, Kim, and Singer (1995) examined the effects of self-controlled KP on the learning of an underhand ball throwing task. The self-controlled group was compared to a yoked group that received feedback according to schedules that matched the requests of the self-control participants. The study also included 50% relative frequency and summary feedback (after every 5 trials) groups as well as a 100% KR control group. During retention, the self-control group threw more accurately than the other four groups, which did not differ from one another. This study provided some of the first evidence that allowing participants to choose when they receive feedback can facilitate motor learning.

Janelle, Barba, Frehlich, Tennant, & Cauraugh (1997) provided additional support for benefits of self-controlled feedback for motor learning. Using a non-dominant arm overhand throw, they compared self-controlled, yoked, and summary KP groups as well as a 100% KR control group. The primary dependent measure was a form score assigned by expert raters. Retention results revealed that the self-control group had significantly higher form scores than the other groups. The beneficial effects of self-controlled feedback have been replicated several times (e.g., Aiken, et al. 2012; Huet, Jacobs, Camachon, Goulon, & Montagne, 2009; Patterson & Carter, 2010).

Important questions have emerged from self-controlled feedback literature related to how learners use feedback and why they decide to request it when they do. Chiviacowsky and Wulf (2002) reported that the majority of self-control participants indicated they asked for feedback mostly after what they perceived to be good trials. Additionally, yoked participants reported they would have preferred to receive feedback after good trials. This preference is contrary to the traditional view that feedback primarily provides information to correct errors and suggests a possible role for confirmatory feedback in facilitating motor learning.

The good-trial feedback preference has not been reported by some studies using more complex tasks. Aiken, Fairbrother, and Post (2012) allowed learners to control the provision of video KP when learning a basketball set shot. They found a self-control advantage for learning, but reported feedback preferences did not align with Chiviacowsky and Wulf (2002). Specifically, self-control participants reported asking for feedback after both good and bad trials equally. Task complexity and the nature of the feedback may account for the difference. Meaningful feedback about form for the basketball set shot cannot be conveyed in a single comprehensive statement. The incorporation of multiple instructional cues for form meant that participants in Aiken et al. could have completed a trial with good performance on one movement element and bad performance on another. Additionally, the use of video KP provided an extremely information-rich mode of feedback that included information about each element of the task. Thus, it is possible that the self-control benefit was tied to the use of feedback for both confirmation and correction. The desire to receive feedback after both good and bad trials when learning complex tasks has also been reported by Laughlin (2012), and Holmberg (2013).

As a follow-up to the good-trial KR preference finding, Chiviacowsky and Wulf (2007) compared the effects of good versus bad trial KR on motor learning. A “good KR” group received feedback about the best three out of six trials while a “bad KR” group received feedback about their worst three trials. The two groups performed similarly in practice, but the “good KR” group was more accurate during the no-KR delayed retention test. This finding was inconsistent with the guidance hypothesis, suggesting a role for feedback that confirms successful performance. In addition to the learning benefit of receiving KR after “good” trials, subsequent studies have also shown evidence of psychosocial benefits. Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki (2012) found that participants who received feedback about good trials had higher self-efficacy than those who received feedback about bad trials. Self-efficacy has received limited attention in motor learning, but the fact that it has consistently been shown to be positively related to performance (Moritz, Feltz, Fahrbach, & Mack, 2000) makes it an important consideration. It is plausible that the opportunity to use feedback to confirm success supports self-efficacy, which in turn might positively influence performance and learning. Badami, VaezMousavi, Wulf, and Namazizadeh (2012) found that feedback after good trials facilitated motor learning and led to higher reports of self-confidence. A related line of research has compared the effects of giving normative (i.e., social-comparative) feedback on learning. Giving positive feedback, whether true or not, has been associated with higher intrinsic motivation (e.g., Deci, 1971; Vallerand & Reid, 1984), but until recently this research has not examined whether performance and learning are also influenced. Lewthwaite and Wulf (2010) found that a group that received false positive normative feedback (indicating their progress was

20% better than average) performed better than a false negative group (indicating their performance was 20% below average) during retention testing. Interestingly, the control group also outperformed the false negative group, suggesting that the negative normative feedback had a detrimental effect on learning. The learning benefit from positive normative feedback has been replicated twice using different tasks (Avila, Chiviacowsky, Wulf, & Lewthwaite, 2012; Wulf, Chiviacowsky, & Lewthwaite, 2010).

Self-efficacy

If confirmatory feedback does facilitate learning, it might operate through increased self-efficacy. In the present study, feedback information was presented that would either confirm success or indicated a need for correction. Presumably, information confirming success might raise self-efficacy, which in turn could influence performance and learning. Accordingly, self-efficacy theory has bearing on the research question addressed in the current study.

Self-efficacy has been defined by different scholars in a variety of ways. Bandura (1997) defined it as “beliefs in one’s capabilities to organize and execute the courses of action required to produce a given attainments” (p. 3). Similarly, Feltz and Chase (1998) defined it as “a person’s perceived capability to accomplish a certain level of performance” (p. 65). In an earlier paper, Feltz (1988) simply referred to self-efficacy as situation specific self-confidence. Central to all of these definitions is the concept of a person self-assessing how certain they are that they can achieve a given skill/task. It is important to note that self-efficacy is not a reflection of the skills individuals possess, but is instead a reflection of what they think they can accomplish with those skills (Bandura, 1986).

Self-efficacy consists of three dimensions: level, strength, and generality (Bandura, 1977). Level, also referred to as magnitude, refers to a challenge or difficulty level that a person feels they can accomplish. Bandura's early work was based on findings from treatments of anxiety and phobias. An example of levels for somebody with a phobia of snakes could be being in the same room as a snake, touching a snake, and picking up a snake. Similarly, in sport it could be about kicking a 30, 40, or 50 yard field goal. Strength refers to how certain a person is that they can accomplish a task. For instance, a kicker might range from 0% to 100% certain that he could kick a 50 yard field goal. The third dimension, generality, refers to how transferrable the efficacy is to other situations. If a field goal kicker is 100% certain he can kick a 30 yard field goal, it is important to know what situations that efficacy generalizes to. Is he certain he can kick it in a rainy game, in the BCS championship game, or just in practice? These three dimensions provide rich information about people's confidence in their ability to perform a task. As will be outlined later, strength and level are the variables most often measured and reported when considering a person's self-efficacy, but that is not to discount the importance of generality. All three dimensions provide useful information for the participant and practitioner.

Bandura's (1977) original model considered four main sources of efficacy information based on the results of intervention studies designed to improve coping with phobias. The four sources proposed by Bandura listed in order from having the greatest to least impact were performance accomplishments, vicarious experiences, verbal persuasion, and physiological states. Other scholars have since modified this list by dividing physiological states into physiological information and emotional states, and adding imaginal experiences as a sixth source. The review here will focus on Bandura's four sources as those have been demonstrated to have the greatest effect on self-efficacy in order to consider how corrective and confirmatory feedback may influence them.

Performance accomplishments, or a person's past experiences with a task, have been shown to have the largest impact on self-efficacy. Bandura (1977) reported that early research on phobia interventions showed that actual exposure training to the particular phobia was more effective than imagined experiences. When considering this finding in sport or motor skills, it is logical that people would be more confident in their ability to do something that they have done previously. Bandura (1977) pointed out that it is slightly more complex than that. Successes with a task have a tendency to increase a person's self-efficacy to accomplish that task again, but with failures it is not as clear cut. Repeated failures, particularly if they occur early in learning tend to have a negative impact on self-efficacy. However, if somebody has had several successful experiences, occasional failures tend not to impact self-efficacy. So in essence, the timing and frequency of failures determine how much impact they will have on self-efficacy. There are potential implications here to giving feedback in motor learning. Feedback frequently emphasizing errors may tend to lower self-efficacy, while feedback confirming successful performances may increase self-efficacy.

In addition to the timing and frequency of an event, another important factor for determining the effect on self-efficacy is how a person perceives the event. To have a positive effect on self-efficacy, a person must first perceive it as a success. For instance, if a learner perceives a low error score as a successful performance, it should increase self-efficacy. However, if it is perceived as not good, or attributed to luck, self-efficacy will not be increased. In the present study, participants received feedback on one element of proper form at a time.

Whether a person perceives that feedback to generalize to good form in general will influence how efficacious that feedback makes them.

Behind performance accomplishments, vicarious experiences are the next most powerful influence on self-efficacy. A vicarious experience in this case is essentially defined as seeing somebody else perform a task successfully (Bandura, 1977). While this is a less dependable source of self-efficacy, it can be very effective in certain situations. When people have little or no experience with a task, they have no performance accomplishments to base their efficacy beliefs on. When this is the case, people rely on the experiences of others to make judgments about what they personally might be able to accomplish (Feltz, Short, & Sullivan, 2008). A weakness of these experiences is they tend to have more a variable impact on self-efficacy because they are based on social comparisons instead of personal past comparisons. The impact of vicarious experiences research on observational learning would be meaningful, but in the current study participants are unlikely to engage in a vicarious experience.

The source of self-efficacy having the third largest impact is verbal persuasion. Verbal persuasion is the act of leading people, through suggestion, into believing they can accomplish what has overwhelmed them in the past (Bandura, 1977). This can occur through encouragement, instruction, evaluative feedback, expectations, and self-talk (Feltz et al., 2008). Verbal persuasion is common in motor learning, and is most often manifested as different types of augmented feedback. Feltz, et al. (2008) point out that feedback emphasizing progress made has a positive influence on self-efficacy, while feedback about shortfalls or errors has a negative influence on self-efficacy. This finding is an important consideration to ponder since a large portion of feedback given in motor learning tends to be corrective in nature. In the present study, Feltz et al.'s predictions would suggest that corrective feedback might lower self-efficacy via verbal persuasion, whereas confirmatory feedback might raise self-efficacy.

As a whole, verbal persuasion has a weaker influence than performance accomplishments and vicarious experiences because it does not have an authentic, experiential base (Bandura, 1977). As a result, even the most influential verbal persuasions can sometimes be overwhelmed by prior experiences of failure. There are a couple of factors that can positively influence the effectiveness of verbal persuasion. A first factor having a major influence is the prestige, credibility, expertise, and trustworthiness of the persuader. To maximize the effectiveness of feedback on self-efficacy, the learner must perceive the person delivering the feedback as competent.

Most researchers report verbal persuasion being most effective when it accompanies performance accomplishments (e.g. Bandura, 1977; Feltz et al., 2008). In the early work with phobia interventions, this was accomplished by a therapist giving encouragement and positive feedback during an experience. In the coaching realm, this is something many coaches do instinctively. When a player does something successfully, the coach provides reinforcement. The combination of these two sources of efficacy makes a powerful contribution going forward.

The fourth source of efficacy outlined by Bandura (1977) is physiological states. The important part with this source is how the person interprets the physiological state. For example, whether a person interprets an increased heart rate as being amped up or being nervous changes the effect on self-efficacy. Similarly, some people may interpret anxiety as being ready to go, while others might interpret it as a precursor to choking. Depending on the interpretation, self-efficacy will either go up or down. This source has a much smaller impact than the above mentioned sources, and is unlikely to play a role in a typical motor learning feedback study.

The combination of these sources leads to a judgment about a person's level of certainty that they can achieve a task. A person's self-efficacy in turn affects a number of outcomes. Research has shown that self-efficacy influences the amount of challenge people seek in performing tasks (Bandura, 1997), the challenge level of goals people set (Locke, Frederick, Lee, & Bobko, 1984), and the likelihood to persist or give up (Feltz et al., 2008). Of particular interest to motor learning researchers is the relationship between self-efficacy and performance. On the surface, it seems logical that greater efficacy beliefs would lead to greater performance. However, in considering practical examples, an overconfident learner will not likely perform very well, and at times an underconfident learner might perform quite well. While some variation exists in findings, the research in general does show a moderate, positive relationship between self-efficacy and performance (Moritz, Feltz, Fahrbach, & Mack, 2000; Feltz & Lirgg, 2001).

Self-efficacy varies from many other related constructs in that there is not one specific validated instrument to measure it. Researchers are instead encouraged to develop a context specific measure based on certain criteria (Bandura, 1977). In developing that instrument, Bandura (1997) recommends measuring self-efficacy on two dimensions: level and strength. Level refers to a varying degree of challenge. This has been conceptualized in a number of ways. Levels are typically classified as hierarchical, but can also be non-hierarchical and focus on different elements of performance (e.g., batting, catching, and pitching). Hierarchical levels can be ordered from least challenging to most challenging, or from least anxiety provoking to most anxiety provoking. Early phobia research considered levels such as being in the same room as a snake, touching a snake, picking up a snake, and putting a snake around your neck. Some research in sport has taken a more quantitative approach to hierarchical levels by using levels such as the ability to make 1 out of 10, 2 out of 10, etc. free throws in basketball. When creating hierarchical levels, Bandura (2006) recommends using pretests to eliminate any items that nearly everyone is completely certain they could accomplish. When such items are included, ceiling effects can be reached making it difficult to detect group differences.

With both hierarchical and non-hierarchical levels, it is important that they be based on a conceptual analysis and knowledge of the challenging requirements of the task. In motor learning research, this could most easily be accomplished by studying the task, consulting with experts within that task domain, and then conducting pilot testing. Taking the time to develop a strong instrument will greatly improve the chances of finding valid, reliable results.

The strength dimension of self-efficacy refers to how certain a person is that they can successfully perform the task at each level. Traditionally this is presented either as a choice from 1-10, or from 0-100% in ten point increments. In the phrasing of the statement, it is important that the instrument ask how certain participants are that they *can* perform the task, not how certain they are that they *will* perform the task (Vealey & Chase, 2008). Underlying self-efficacy theory is the concept of a belief in a capability, not an intention to act.

When measuring self-efficacy, researchers and practitioners have the option to report self-efficacy level, self-efficacy strength, or both measures. Self-efficacy level is simply the highest level (in a hierarchical measure) that the participant indicated greater than zero percent certainty he/she could accomplish the task. Self-efficacy strength is calculated by taking the mean of the self-efficacy strength scores at all levels the participant did not score a zero. This can be reported as a percentage (e.g. 44%), and can be interpreted as 44% confidence in the ability to complete the task. Self-efficacy strength is a more sensitive measure, and as a result is the more commonly reported value.

Summary

The above review of literature provides a background and rationale for considering the role of corrective and confirmatory feedback in motor learning. Findings emerging from research on bandwidth, self-controlled, good and bad trial, and normative feedback provide a challenge to the traditional view that the role of feedback in learning is one of error correction. Preliminary evidence suggests that in some settings, feedback that confirms success may facilitate learning. One potential mechanism for such a benefit is increased self-efficacy. The present study was designed to test the combined and independent effects of corrective and confirmatory feedback, and to determine to what extent those findings can be interpreted through differences in self-efficacy.

CHAPTER 3

Method

Participants

A total of 39 apparently healthy students volunteered from undergraduate and graduate courses in the Department of Kinesiology, Recreation, and Sport Studies. One person was excluded because of prior soccer experience, and two were excluded for failing to return for the second day of the study. In total, 36 participants (21 females, 15 males) completed the entire study. Participants had no prior experience with the soccer throw-in task, did not play organized soccer at the high school level or higher. Each participant completed a written informed consent form (Appendix A), which was approved by the University of Tennessee Institutional Review Board. Participants were randomly assigned to one of three experimental groups (n = 12 per group) with equal numbers of males (n =*5*) and females (n =*7*) in each group.

Task and Apparatus

The task was a one-step soccer throw-in skill adapted from Weeks and Kordus (1998) using a size 5 soccer ball measuring between 68.5 and 69.5 cm in circumference, and weighing between 420 and 445 gr (FIFA.com). Participants threw the ball at a cone measuring 35cm in diameter and 75 cm in height. The cone was placed on the center of a plywood target measuring 2.5 m x 2.5 m. The target had three concentric squares around the cone increasing in diameter by 70 cm each. Two digital camcorders (Canon ZR 960; Canon, USA, Inc., Lake Success, NY) captured the movement of the participant during each trial. One camera was placed 3 m directly behind the participant and aimed slightly upward to capture both the upper body movements of the participant and the flight of the ball. The second camcorder was placed directly to the left of the participant at a distance of 4 m to capture the entire movement from a side view. Camcorders were connected directly to a secure personal computer, and trials were captured, recorded, and reviewed using Silicon Coach Pro Software (Silicon Coach Ltd., Dunedin, New Zealand).

Instruments

For self-efficacy, participants were asked how certain they were (from 0-100% in 10 point increments) that they could achieve progressively more challenging form scores. For each phase, strength of self-efficacy was analyzed. Strength of self-efficacy is an average of all scores reported by a participant. Based on the recommendations of Bandura (2006), pilot data was collected to determine if there was a level that most participants had 100% confidence they could achieve. Levels at or below this level (e.g., form score of 1/8 and 2/8 here) were eliminated from the instrument to avoid ceiling effects in self-efficacy strength.

Procedure

Upon arrival to the laboratory, participants read and signed a written informed consent form (Appendix A) and verbally confirmed that they had no prior experience with the soccer throw-in skill. Participants were then randomly assigned to either the corrective feedback (CORR), confirmation feedback (CONF), or the sandwich (SAND) group. The experimenter then explained that their goal was to learn the correct technique of the soccer throw-in skill. Participants were told that during the acquisition phase, they would be given feedback about their form, but during the retention and transfer phases no feedback would be given. It was further emphasized that throughout all phases of the experiment the primary goal was to throw with correct form.

Prior to starting the acquisition phase, participants changed into fitted clothing that allowed for reliable identification of anatomical landmarks. A square piece of medical tape measuring 3.81cm on each side was placed on the greater trochanter of the left femur. A second piece of tape of equal size was placed just below the termination of the posterior axillary fold. These markers were used as reference points for completing form ratings.

Participants viewed a video of a skilled performer completing the task in the same practice environment. Males viewed a male performer, and females viewed a female performer. Following the video demonstration, participants completed a two throw pretest. For the first pretest throw, participants were instructed to throw the ball as far as possible using the technique shown in the video demonstration. For the second throw, the target was placed at 75% of the distance achieved in the first throw and participants were instructed to hit the cone or throw the ball as close as possible to the cone. The experimenter recorded distance for Throw 1 and accuracy for Throw 2. Both throws were videotaped.

After the pretest, the experimenter read aloud the eleven elements of proper form shown in Table 1. Additionally, each element was presented on a piece of paper with a written statement and a photograph demonstrating proper execution. The eleven elements were adapted from those used in Weeks and Kordus (1998). The final statements were developed using input from soccer coaches and players and the results of pilot testing. Once the eleven statements were developed, two NCAA soccer coaches and one youth soccer coach evaluated each statement and ranked them from most important to least important. Following instruction about the elements of proper throwing form, participants completed the first administration of the Self-Efficacy Questionnaire (Appendix B), and were given an opportunity to ask any questions prior to the start of the acquisition phase of the experiment.

The acquisition phase consisted of 30 trials throwing at a target placed at 75% of the distance of each participant’s first pretest throw. It was emphasized that the primary goal was to throw with correct form, while a secondary goal was to throw accurately.

Table 1

Frequency of KP administration for each element of form

Form Cue	CORR	CONF	SAND +	SAND -
1. Feet should remain on the ground	10.56%	61.94%	88.33%	11.67%
2. The ball should start behind the head at the beginning of the throw	0.56%	37.22%	11.67%	0.28%
3. The ball should go directly over the head during the throw with both arms contributing equally	33.61%	0.56%	0%	26.39%
4. The back should be arched to put the body in a “C” position	17.50%	0%	0%	20.56%
5. The front foot should contact the ground before any trunk or arm flexion	0.83%	0%	0%	1.94%
6. Movement should be initiated from the trunk	1.67%	0.28%	0%	0.28%
7. The arms should be together and aimed at the target at the end of the throw	22.22%	0%	0%	16.94%
8. The feet, hips, knees, and shoulders should be aimed at the target, feet shoulder width apart	0.56%	0%	0%	0.83%
9. The grip should look like a “W” with thumbs together on the back of the ball	2.78%	0%	0%	3.61%
10. The ball should be released just in front of the head	6.94%	0%	0%	7.78%
11. There should be no spin on the ball during flight	2.78%	0%	0%	9.72%

* Form elements are presented in order from most important to least important

Following each trial, participants received feedback related to the eleven elements of correct form introduced earlier in the experiment. Participants in the confirmation feedback group (CONF) received feedback on the most critical form component they performed correctly. Those in the correction group (CORR) received feedback on the most critical error in their form. The most critical form element in each case was determined by the experimenter reviewing video of the trial and choosing the highest ranking form element that was performed either correctly or incorrectly. For example, if the video showed that a participant kept both feet on the ground, the feedback they received was, “On that trial, one thing that was correct is that both feet remained on the ground.” Participants in the sandwich feedback group (SAND) received feedback on the most critical form component performed correctly followed by feedback about their most critical error.

Prior to each trial, the experimenter verbally confirmed the participant was ready, started the video cameras, and instructed the participant to take the throw. Immediately after the throw, the experimenter recorded the accuracy score. Throws hitting the cone were scored as four points, and each successive zone on the target decreased by one point (i.e., 3, 2, 1). Throws missing the target entirely were scored as zero. After each throw, the participant was asked to retrieve the soccer ball, and the experimenter reviewed video of the throw on a computer to determine which form element about the feedback would emphasize. Video was reviewed in both real time and frame by frame. The researcher reviewed the form elements in the order ranked by coaches, and provided feedback on the highest ranking element performed correctly (CONF), the highest ranking error (CORR), or both (SAND). Following feedback delivery, the participant moved into position for the next throw. At the conclusion of the thirty trials, participants were reminded of the time to come back for the retention and transfer phases on the following day. Upon dismissal from the first day of the experiment, participants were instructed not to practice the task outside of the experiment.

Approximately 24 hours after the completion of the acquisition phase, participants returned for the retention, short transfer, and long transfer phases. Prior to each phase, participants completed the Self-Efficacy Questionnaire (Appendix B). For each administration, participants were asked to answer the questions specifically in reference to the phase that was about to be completed. For example, in the short transfer phase, participants considered how they felt about throwing at a shorter distance. The retention phase consisted of five trials throwing at the same target distance used in acquisition. The only difference between the acquisition and retention phases was that participants received no feedback about their form. Following the completion of the retention phase, participants rested for five minutes, and then completed the short transfer phase. In this phase, participants took five throws at a target placed at 50% of the distance used during acquisition. Again, participants did not receive feedback about their form. Following this phase, participants again rested for five minutes, and then completed the long transfer phase. This phase consisted of five throws throwing at a target at the same distance thrown in the first pretest throw (i.e., the throw for maximum distance). Prior to all three phases, participants were reminded that the primary goal was to throw with correct form, while the secondary goal was to throw accurately. Following the long transfer phase, participants completed the Post-Experiment Questionnaire (Appendix C) and then debriefed about the purpose of the study.

Data Treatment and Analysis

The primary dependent measure used during all phases of the experiment was form score. Consistent with the procedures of Weeks and Kordus (1998), form scores were assessed by two research assistants who were naïve to the purpose of the study. Raters viewed clips in a random order, and were unaware of experimental group or phase. Interrater reliability was assessed using an intraclass correlation (ICC) to assure consistency in scoring. Across all conditions, the scores calculated by the raters had an ICC of .83, indicating good consistency between raters. Form scores were based on the eleven form components listed in Table 1. One point was awarded for each element performed correctly. The exception was Element 9 (At the end of the throw the arms should be together and aimed at the target) for which a half point was awarded if the arms were together, but not aimed at the target, or if they were aimed at the target, but not together. Scores for each element were totaled with a maximum score of eleven for each trial. Final form scores were calculated by taking the mean score of the two raters.

Throwing accuracy was included as a secondary dependent measure. With the focus of the experiment being on developing correct form, accuracy scores were a less meaningful measure, but were measured in the event that more proficient form in one group also led to superior accuracy. Accuracy was measured for each trial as outlined above, with each trial receiving a score of 0-4.

Data from each phase of the experiment (pretest, acquisition, retention, accuracy transfer, and distance transfer) were analyzed separately. Pretest form scores and accuracy were analyzed using separate univariate analyses of variance (ANOVA) to ensure no initial differences existed between groups. For acquisition, form and accuracy were analyzed using a 3 (Group) x 6 (Block) doubly multivariate repeated measures analysis of variance (MANOVA). Follow-up 3 (Group) x 6 (Block) univariate repeated measures ANOVAs were conducted separately for each dependent variable. Where significant effects and interactions occurred, Sidak multiple comparisons were used as a follow-up test to determine the source of those differences.

For retention, short transfer, and long transfer, form and accuracy were analyzed using separate univariate MANOVAs comparing groups. Each significant MANOVA was followed up by separate univariate ANOVAs comparing groups. Where significant effects and interactions occurred, Sidak multiple comparisons were used as a follow-up test to determine which groups differed from each other.

Self-efficacy was measured at four different time points: prior to the acquisition, retention, short transfer, and long transfer phases. Self-efficacy was analyzed using a 3 (Group) x 4 (Test) univariate analysis of variance (ANOVA). Where significant effects and interactions occurred, Sidak multiple comparisons were used as a follow-up test to determine the source of those differences. Cronbach's alpha was calculated to ensure internal consistency between measures of self-efficacy at different time points, and indicated excellent internal consistency ($\alpha = .94$).

Responses from the Post-Experiment Questionnaire were analyzed using separate univariate ANOVAs comparing groups. Sidak multiple comparisons were used as a follow-up test to determine the source of those differences. Qualitative data from the four open-ended responses were included for descriptive purposes (Appendix D). In all analyses, when sphericity was violated, Greenhouse-Geisser *df* adjustments were used. The alpha level for all analyses was set at .05.

CHAPTER 4

Results

In this chapter, the results of the present study are discussed. These include form and accuracy scores during the pretest, acquisition, retention, short transfer, and long transfer. Also discussed is self-efficacy at different time points in the experiment, and responses to the Likert scale items of the Post-Experiment Questionnaire (PEQ). Responses to open-ended items on the PEQ are presented in Appendix D.

Pretest

During the pretest, all three groups produced similar form (M = 5.15; SD = 1.49) and accuracy (M = 1.78; SD = 1.40) scores. These observations accounted for the lack of significant differences in the MANOVA, $\Lambda_{\text{Wilk's}} = .86$, $F(4, 64) = 1.21$. Since no group differences existed, follow-up tests were not warranted.

Acquisition

Figures 1 and 2 show mean form and accuracy scores for the CORR, CONF, and SAND groups during acquisition. The MANOVA revealed a significant main effect for group, $\Lambda_{\text{Wilk's}} = .72$, $F(4,64) = 2.86$, $p = .03$, $\eta^2 = .152$. Neither the main effect for block, $\Lambda_{\text{Wilk's}} = .53$, $F(10,24) = 2.15$, nor the Group × Block interaction, $\Lambda_{\text{Wilk's}} = .35$, $F(20,48) = 1.68$, were significant. Follow-up analysis for the group main effect were conducted using separate 3 (Group) x 6 (Block) ANOVAs with repeated measures on block for form and accuracy scores. The CORR and CONF groups had the highest and lowest mean form scores, respectively, during acquisition. The mean form scores for the SAND group fell in between the CORR and CONF groups. These observations accounted for a significant main effect for group, $F(2,33) = 6.12$, $p = .005$, $\eta^2 = .271$. Post hoc comparisons revealed significantly higher form scores for the CORR group compared to the CONF group (p = .005). The SAND group did not differ from the other groups. Neither the main effect for block, $F(5,165) = 2.08$, nor the Group × Block interaction, $F(10,165) = 1.62$, were significant.

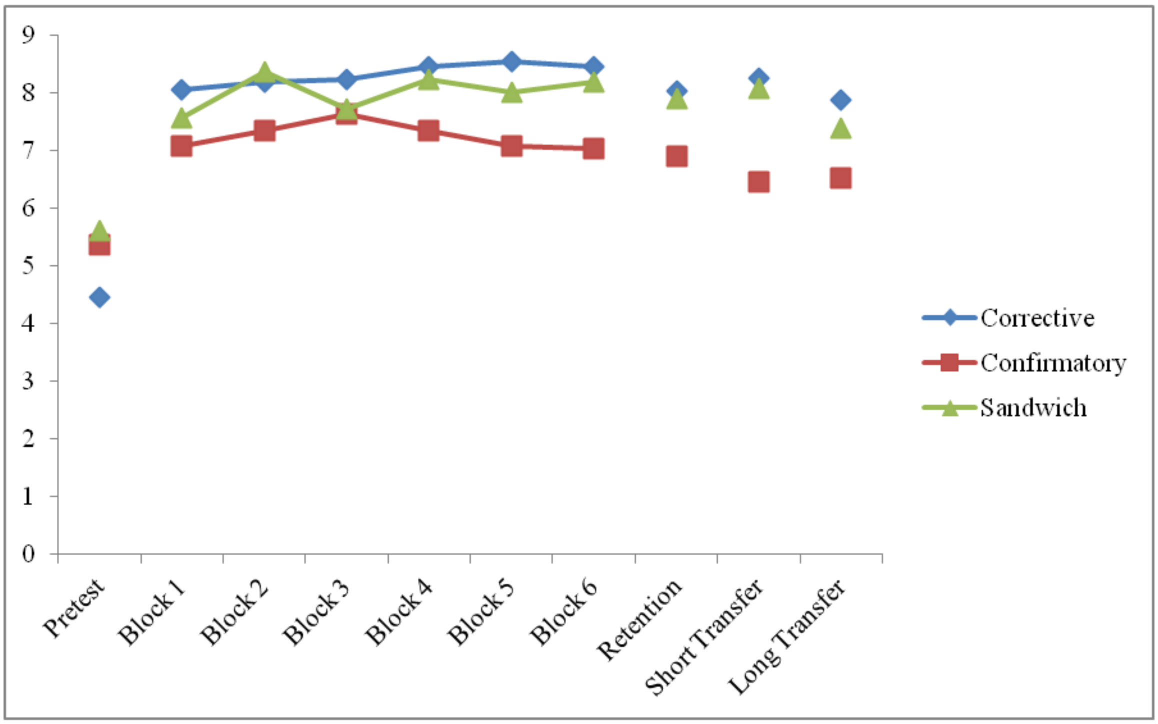

Figure 1

Mean form scores for the CORR, CONF, and SAND groups during each phase of the experiment.

For accuracy scores, the group effect, $F(2,33) < 1$, and the Group x Block interaction, $F(10,165) < 1$ were not significant. There was a significant Block effect, $F(5,165) = 3.50$, p = .005. Post hoc comparisons showed that block 1 (M = 2.02, SD = .78) was significantly different from block 5 (M = 2.53, SD = .86), p = .015, and block 6 (M = 2.52, SD = .89), p = .009, giving evidence that participants' accuracy improved over acquisition.

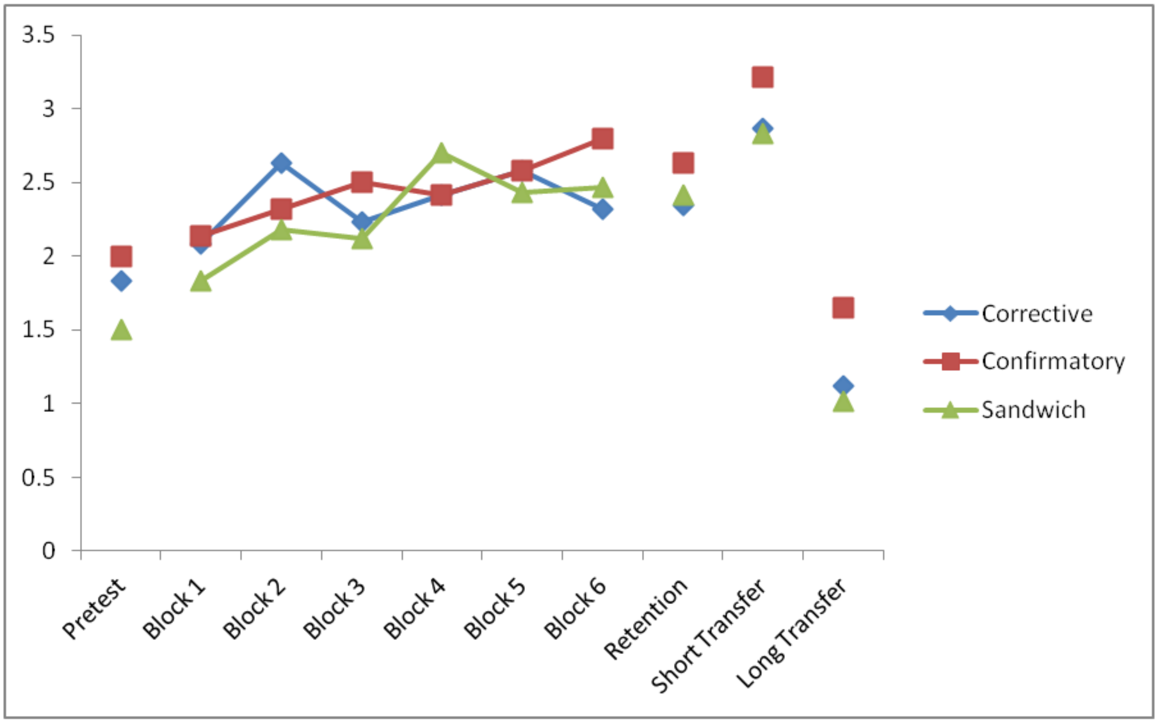

Figure 2

Mean accuracy scores for the CORR, CONF, and SAND groups during each phase of the experiment.

Retention and Transfer

Figures 1 and 2 show mean form and accuracy scores for the CORR, CONF, and SAND groups during retention, short transfer, and long transfer. The linear combination of form and accuracy during retention and transfer phases differed between groups as evidenced by a significant group main effect on the MANOVA, $\Lambda_{\text{Wilk's}} = .64$, $F(4,64) = 4.08$, $p = .005$, $\eta^2 = .203$. Scores also differed across the three tests, as evidenced by a significant test main effect on the MANOVA, $\Lambda_{\text{Wilk's}} = .24$, $F(4,30) = 23.30$, $p < .001$, $\eta^2 = .756$, but the Group x Test interaction, $\Lambda_{\text{Wilk's}} = .84$, $F(8,60) = .682$, was not significant.

To determine the source of group differences on the MANOVA, separate 3 (Group) x 3 (Test) repeated measures ANOVAs with repeated measures on test for Form Score and Accuracy were conducted. The three groups differed in form scores across all three tests, $F(2,33) = 8.21$, $p = .001$, $\eta^2 = .332$. Post hoc comparisons indicated that across all three tests, the correction group ($M = 8.07$, $SD = .77$) and the sandwich group ($M = 7.80$, $SD = .93$) did not differ from each other, $p > .05$, but each had significantly better form than the confirmation group ($M = 6.64$, $SD = 1.04$), *p*'s = .002 and .012 respectively. Groups did not differ on accuracy scores, $F(2,33) = 2.32$.

Form scores and accuracy were analyzed in separate 3 (Group) x 3 (Test) repeated measures ANOVAs with repeated measures on Test to determine the source of the significant test effect in the MANOVA. Participants' form scores did not differ across tests, $F(2,66) = 2.96$. However, for accuracy scores did differ across the three tests, $F(2,66) = 56.34$, $p < .001$, $\eta^2 = .631$. Post hoc comparisons indicated that participants threw more accurately in Short Transfer ($M = 2.97$, $SD = .71$) than in Retention ($M = 2.47$, $SD = .78$), $p = .009$, and Long Transfer ($M = 1.26$, $SD = .86$), $p < .001$. Further, they were more accurate in Retention than in Long Transfer, $p < .001$.

Self-Efficacy

Figures 3 shows mean self-efficacy scores for the CORR, CONF, and SAND groups throughout the experiment. A 3 (Group) x 4 (Test) univariate repeated measures ANOVA with repeated measures on Test was conducted on self-efficacy. The three groups did not differ from each other, $F(2,32) = 2.29$, $p > .05$. Participants scores did change across tests, $F(1.64,52.57) = 5.05$, $p = .014$, $\eta^2 = .136$. Self-efficacy was higher during short transfer ($M = 55.05$, $SD = 18.56$) than in retention ($M = 50.35$, $SD = 18.48$), $p = .016$, and in long transfer ($M = 48.16$, $SD =$

17.60), p = .001. The Group x Test interaction failed to reach significance, $F(3.29,52,57) = .880$, $p > .05$.

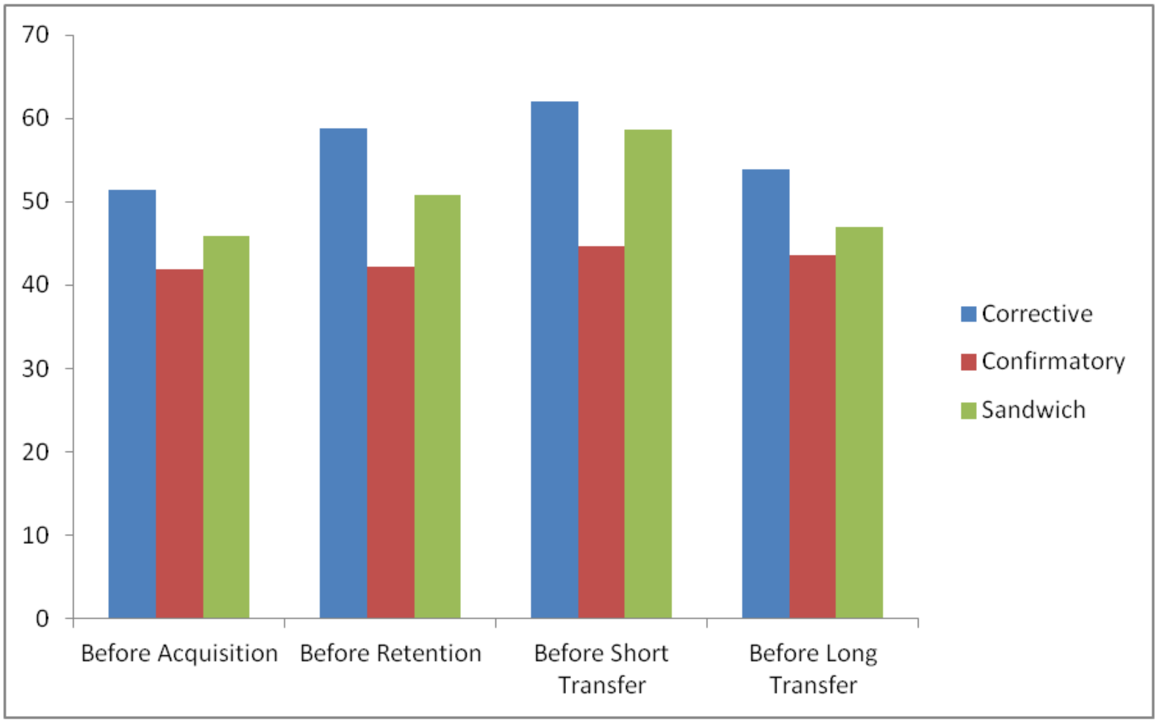

Figure 3

Mean self-efficacy scores for the CORR, CONF, and SAND groups at the four different test administrations.

Post Experiment Questions

Means and standard deviations for each question can be found in Table 2. A between-groups univariate ANOVA on the responses for question #6 revealed a significant group main effect, $F(2,33) = 13.72$, $p = .001$, $\eta^2 = .384$. The sandwich group (M = 5.92, SD = 1.31) reported finding the confirmatory feedback more helpful than the confirmation group (M = 3.75, SD = 1.54). Additionally, the responses of questions 5 and 6 were combined to represent the helpfulness of the feedback in general. A univariate ANOVA on this data revealed a significant group effect, $F(2,33) = 8.29$, $p = .001$, $\eta^2 = .334$. Post hoc comparisons indicated that the sandwich group ($M = 5.67$, $SD = 1.30$) and the correction group ($M = 5.75$, $SD = 1.22$) did not differ from each other, but both found the feedback more useful than the confirmation group ($M = 3.75$, $SD = 1.54$), p's = .005 and .003 respectively. Analyses of all other question responses revealed no significant differences between groups.

Table 2

Means and Standard Deviations for Responses to Quantitative Post-Experiment Questions

Question	Corrective	Confirmatory	Sandwich
1. How competent do you think you are at the soccer throw-in?	5.33 (.89)	4.42 (1.16)	5.00 (1.35)
2. How do you feel your current skill in this task compares to when you first started the experiment?	5.25 (.87)	5.50 (.80)	5.17 (1.11)
3. To what extent were you concerned with throwing with proper form?	5.75 (.87)	6.00 (.85)	5.25 (1.06)
4. To what extent were you concerned with throwing accurately?	5.08 (1.56)	5.33 (1.15)	5.25 (1.46)
5. For improving your form, how useful was it when the researcher told you what you did correctly?	n/a	3.75 (1.54)	5.92 (1.31)
6. For improving your form, how useful was it when the researcher told you what you did incorrectly?	5.75 (1.22)	n/a	5.42 (1.56)
7. How did the feedback you received from the researcher affect your confidence about performing the task?	4.08 (1.08)	3.75 (1.36)	4.08 (1.88)
8. How did the feedback you received from the researcher affect your motivation to learn the task?	5.50 (.90)	5.17 (1.27)	5.17 (1.47)
9. How did the feedback you received from the researcher affect your level of enjoyment in practicing the task?	4.42 (.67)	3.58 (1.08)	4.33 (1.61)

CHAPTER 5

Discussion

The purpose of this study was to test the combined and independent effects of corrective and confirmatory KP on the learning of a novel motor skill. Based on previous literature, there were multiple possible outcomes. Traditional viewpoints recognize feedback as a means to correct errors, thus suggesting that corrective KP would be more beneficial than confirmatory KP. Recent research showing an advantage to receiving feedback after so-called good trials (Chiviacowsky & Wulf, 2007) suggests there may also be a benefit to feedback confirmatory KP. There is also preliminary evidence suggesting that confirmatory KP might increase self-efficacy, which may in turn facilitate learning (Saemi et al., 2012). It was hypothesized that group receiving both corrective and confirmatory KP (SAND) would achieve the highest form scores during all phases of the experiment because participants received corrective information as well as possible increases in self-efficacy via the confirmations of success. This hypothesis was consistent with the interpretation that the benefit bandwidth (e.g., Sherwood, 1988) and normative feedback (e.g., Lewthwaite & Wulf, 2010) may have been in part due to the combination of correction and confirmation. It was also hypothesized that the CORR group would achieve higher form scores compared to the CONF group because the KP would allow them to correct their errors. Finally, it was also predicted that both the SAND and CONF groups would report higher self-efficacy for their throwing form as a result of the reinforcement they received.

The most important finding of this experiment was that corrective feedback was more effective than confirmatory feedback in the performance and learning of a complex motor skill. Those who received corrective feedback threw with better form throughout acquisition, retention, and both transfer phases of the experiment. This finding supports the traditional viewpoint that feedback operates by providing error information so that learners can adapt their movements to more closely meet the movement goal (Salmoni et al., 1984). In learning a complex skill like a soccer throw-in, there are a number of movement components that need to be mastered to demonstrate proper form and mastery is unlikely to occur without some corrective information. This finding converges with Aiken et al.'s (2012) finding that when given the choice, participants choose to use corrective feedback when learning movement form for a complex task. Participants in the present study indicated a similar preference. In the Post-Experiment Questionnaire, nearly all participants in the CONF group reported wanting feedback about what they did incorrectly. While the confirmatory feedback may have had some value, participants seemed to recognize the need for corrective information to improve their throwing form during practice.

The current results were not consistent with Chiviacowsky and Wulf's (2007) report that feedback after so-called good trials facilitated learning. One reason for this discrepancy may have been related to differences in the tasks used. Chiviacowsky & Wulf asked participants to complete an underhand beanbag tossing task, which required the coordination of relatively few degrees of freedom. Simple tasks often reduce the number of movement elements that are free to vary, increasing the likelihood of success on any given attempt. Confirmatory feedback could then reinforce a successful movement and encourage the learner to replicate it in the future. In contrast, the soccer throw-in task in the current study required whole body coordination and allowed for errors in at least 11 distinct movement elements. Accordingly, there are more ways to commit an error on any given trial, reducing the likelihood that confirmatory feedback will reinforce overall desired movement behavior. Another important issue relates to a possible distinction between good-trial and confirmatory feedback. The current study was designed to examine the implications of a specific interpretation of observations that feedback after good trials was preferred and beneficial to learning. Specifically, Chiviacowsky and Wulf (2007) argued that the good-trial KR benefit was related to the fact that it conveyed information to the learner about success. It may be the case, however, that a learner's estimation of what constitutes "good" performance differs fundamentally from what a coach or instructor might identify as a relatively "correct" performance. .

Chiviacowsky and Wulf (2007) operationalized "good" and "bad" trials as either the best or worst three trials in each block of six. Participants were not informed about the nature of the feedback they received. It is possible that the good-trial KR group received information that could be considered confirmatory feedback on some trials and corrective feedback on others. Moreover, the relationship of the information to objective performance standards could have varied dramatically across participants regardless of group. For example, a very proficient participant in the bad-trial KR group would have received information confirming accuracy more so than a poor performer in the good-trial KR group. Chiviacowsky and Wulf also noted the potential role of motivation in the good-trail feedback benefit. Presumably, participants receiving feedback about their best three trials would on average receive a more positive representation of their proficiency in meeting the task goal. The results of the current study indicating that confirmatory feedback did not facilitate learning compared to corrective feedback indicate that further research is needed to more fully understand the efficacy of providing feedback after good trials.

Another important result from this study was the finding that the SAND group was no more successful than the CORR group in achieving proper throw-in form. In light of the purported benefit of good-trial feedback, it was suggested in the introduction that previous research on bandwidth f and false normative feedback could be reinterpreted as potentially resulting from the *combined* effects of confirmatory and corrective feedback. Bandwidth feedback provides corrective information when performance falls outside the bandwidth and implicitly confirms success when it falls within the bandwidth. The results of this study did not support this idea.

Two important differences exist between the combined feedback used in the present study and that seen in bandwidth and false normative feedback. First, the current study presented the combined feedback after each trial. In a bandwidth feedback protocol, however, participants receive either corrective or confirmatory information after each trial. Thus, it is possible that combining corrective and confirmatory feedback is more effective when the two are administered after separate trials. Aiken et al. (2012) reported that self-control participants requested feedback after both good and bad trials for a complex task, which suggests that identifying alternative ways of delivering both types of information might be a fruitful avenue for future research. . The second difference related to the specificity of the confirmatory information that was presented. In both the bandwidth and false normative feedback protocols, the information confirming success is very broad in nature. Specifically, feedback indicates overall success compared to either the task goal or to peers. In the present study, the information confirmed success relative to a specific set of objective movement criteria (i.e., the confirmation of success in completing 1 out of 11 elements of proper form). It is possible that such narrowly focused feedback simply did not provide enough information to facilitate learning. Additionally, informing a participant that one element was performed correctly might prompt an inference the other elements were not.

It is important to note, however, that the sandwich approach (i.e., confirming and correcting) produced similar effects compared to corrective KP alone. It is possible that the study was too short to produce an additive benefit of confirmation when combined with correction. If even a small benefit accrued over the long term, learners could potentially benefit from using some form of the sandwich approach. The limited amount of evidence available suggests that perhaps confirmation feedback should be more general in nature. For example, for the throw-in, a feedback statement might be, "Overall that was good form. Your back did not have the "C" position, but overall good form". Future research is needed to examine whether this approach would be more effective than correction alone.

One potential reason for the absence of a confirmatory feedback benefit was related to the self-efficacy findings. Contrary to the prediction, no group differences in self-efficacy were observed. It was hypothesized that the CONF group would experience a boost in self-efficacy from receiving information confirming success. In previous work, Saemi et al. (2012) found that feedback after good trials elevated self-efficacy compared to feedback after bad trials. Additionally, the largest predictor of self-efficacy is previous mastery experiences (Bandura, 1977), and so it was plausible that confirmation of success would increase the likelihood that participants would perceive themselves to have had a mastery experience. There are a number of possible reasons why the confirmatory feedback did not influence self-efficacy differently than the corrective feedback. The narrowly focused confirmatory feedback statements probably did not convey a general sense of success related to mastery. Indeed, some participants even reported thinking that the focus on one element meant the other 10 were incorrect. Presumably, such a misunderstanding could actually decrease self-efficacy for some participants. One limitation in measuring self-efficacy was the mismatch between the specificity of feedback statements and the general proficiency focus of the self-efficacy instrument. In previous research, less complex tasks allowed the feedback to be more closely aligned with the self-efficacy measure. For example, Saemi et al. (2012) provided KR about throwing accuracy and measured self-efficacy beliefs about that accuracy. Thus, the feedback directly reinforced a general sense of proficiency. In the present study, the self-efficacy instrument measured beliefs about throw-in form as a whole while the feedback statements focused on only one out of eleven movement elements. This gap in specificity left the participant to speculate about their true overall proficiency in producing the correct movement form. The measurement of self-efficacy might also have been compromised by the short training period. Although previous motor learning literature has shown effects in self-efficacy using simpler tasks, the complexity of the current task may have required more extensive practice to result in mastery experiences.

The examination of post-experiment questions revealed a difference in how useful the three groups found the feedback. The SAND and CORR groups found the corrective feedback similarly useful. However, the CONF group differed from the SAND group in terms of how effective they found the confirmatory feedback. Specifically, the CONF group reported the confirmatory feedback as less effective than the SAND group. This finding indicates that the use of confirmatory feedback may be of some value, at least from the learner’s perspective, as long as it is accompanied by corrective information.

In conclusion, the results indicated that corrective information is critical for learning complex motor skills. Simple tasks may lend themselves to stumbling upon a correct response, which is then reinforced by confirmatory feedback, but complex tasks are more likely to require corrective feedback to guide the learner to proper form. The confirmatory feedback in the current study did not promote higher self-efficacy than corrective feedback. More general confirmatory feedback may be more effective in doing so. Indeed, the narrowly focused feedback used in this study could actually have undermined self-efficacy for some participants. The results of this study hold important implications for practitioners. The sandwich approach employed in this study was one potential implementation of recommendations from Weinberg and Gould (2011). It seems, however, that a sandwich approach incorporating more general praise or broad confirmation of success might be more effective. This method would be consistent with the approach seen in some sport and physical education settings designed to deliver corrective information while supporting the affective needs of the individual. Another implication is that practitioners should not be afraid to use corrective feedback alone. The results here show the effectiveness of this approach in supporting learning, and the open ended responses in Appendix D support the fact that learners are interested in receiving corrective information.

Summary of Procedures

Upon arrival to the laboratory, participants confirmed they had not played soccer at the high school level or higher, signed a written informed consent (Appendix A), and were introduced to the experimental task and procedures. Participants completed a two throw pretest, and then were introduced to the eleven elements of good form, completed the first perceived competence and self-efficacy assessment, and then completed 30 acquisition trials. Following each trial participants either received feedback about their most critical error (CORR), the most critical form component performed correctly (CONF), or both (SAND). After the 30 trials, participants were instructed not to practice the task outside of the experiment, and then returned approximately 24 hours later for retention and transfer phases of the experiment. The retention phase consisted of five trials throwing at the same target distance with no feedback. The short and long transfer were the same, with the exception that the target was placed at a distance 25%

shorter, and then 25% longer than the acquisition and retention target distance. Prior to each testing phase, participants completed the perceived competence and self-efficacy assessment. Following the experiment, they completed the post-experiment questionnaire.

Summary of Findings

The experiment revealed significant differences between groups for form scores, but did not find group differences in perceived competence, self-efficacy, or accuracy. Post-experiment questions revealed a group difference in the usefulness of feedback.

Form

A group main effect was present in acquisition, $F(2,33) = 6.12$, $p = .005$, $\eta^2 = .271$. Follow-up Sidak multiple comparisons indicated that across acquisition, the correction group had significantly better form than the confirmation group, $p = .005$ while the sandwich group did not differ from either group, $p > .05$.

During testing phases, a group main effect was present, $F(2,33) = 8.21$, $p = .001$, $\eta^2 = .332$. Follow-up Sidak multiple comparisons indicated that across all three tests, the correction group ($M = 8.07$, $SD = .77$) and the sandwich group ($M = 7.80$, $SD = .93$) did not differ from each other, $p > .05$, but each had significantly better form than the confirmation group ($M = 6.64$, $SD = 1.04$), p's = .002 and .012 respectively.

Self-Efficacy

A 3 (Group) x 4 (Test) univariate repeated measures ANOVA with repeated measures on Test was conducted on self-efficacy. The group main effect failed to reach significance, $F(2,32) = 2.29$, $p > .05$.

Usefulness of Feedback

A univariate ANOVA on this data revealed a significant group effect, $F(2,33) = 8.29$, $p = .001$, $\eta^2 = .334$. Sidak multiple comparisons indicated that the sandwich group ($M = 5.67$, $SD = 1.30$) and the correction group ($M = 5.75$, $SD = 1.22$) did not differ from each other, but both found the feedback more useful than the confirmation group ($M = 3.75$, $SD = 1.54$), p's = .005 and .003 respectively.

Conclusions

The findings of the present study suggest the following conclusions:

1. For the learning and performance of a complex motor skill, knowledge of performance feedback that corrects errors is more effective than knowledge of performance feedback that confirms success.
2. Combining corrective and confirmatory feedback together in the sandwich approach used here does not appear to provide superior learning when compared to corrective feedback alone.
3. Self-efficacy was not increased as a result of receiving confirmatory feedback about one out of eleven elements of proper form.
4. Feedback that includes corrective information was rated as more useful than feedback only confirming successful movement elements.

Limitations

The present study does have some practical limitations. First, the range of movement form elements included in the feedback was not consistent across groups. The CORR and SAND groups received information about a wider range of movement elements than did the CONF group and it is possible that this contributed to the observed effects. The feedback schedule implemented here was based on how critical each form element was to successful performance of the task. This process standardized which feedback statement the experimenter gave and controlled for experimenter bias in choice. Second, some of the 11 movement form elements had more intrinsic feedback available than others. For example, a participant could likely determine on their own if the ball was spinning or if their feet stayed on the ground. This opened up the potential that some feedback statements could have been more redundant than others.

Future Directions

Future research is certainly warranted to further explore the potential benefit of the sandwich approach to delivering feedback. One potential avenue is using a similar design as the present study, but finding a way to control for the variability in feedback across conditions. If the confirmatory feedback used in the sandwich approach was more variable, it may become less redundant and have greater value to the learner. In applied settings, coaches and practitioners would likely not constrain themselves to giving feedback just about the most critical component of form performed correctly, thus allowing for greater variability in confirmatory feedback.

It may also be of value to explore the benefit of a sandwich feedback schedule with more general positive information. For example, a researcher might say, “On that throw your form was very good. One thing you could improve is getting the ball to travel directly over your head, but good form overall.” This general information about the quality of the movement might invoke a positive perception of the learner’s ability to throw with good form and provide a learning benefit similar to that seen by Chiviacowsky and Wulf (2007), and Lewthwaite and Wulf (2010).

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APPENDICES

Appendix A

Informed Consent Form

An experiment to examine the role of feedback in learning

The purpose of this research study is to investigate how feedback influences the learning of a motor skill. During the study, you will participate in two separate data collection sessions held on two consecutive days. The first session will last approximately 45 minutes and the second session will last approximately 30 minutes. During each session, your performance of the motor skill will be videotaped to be used for later form rating. All data from your performance will be recorded and stored on a secure personal computer for later analysis.

The task you will learn will require you to perform a soccer throw-in. During the first session, you will complete 30 trials of the task. Approximately 24 hours later, you will return for the second session, in which you will 15 trials of the same task to assess your learning. At four times throughout the experiment, you will be asked to complete a short questionnaire about how certain you are about your capability to perform the task. At the completion of the experiment, you will be asked to answer some questions about your experience and have the opportunity to learn more about the research project.

If you volunteered for this experiment through the SONA Experiment Management System in exchange for course credit, your participation will be reported to that website. The experimenters conducting this study are not directly involved in awarding course credit. They simply report whether or not you participated in the study.

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. No reference will be made in oral or written reports that could link you to your performance or to the study. The results of this study will contribute to a better understanding of motor skill acquisition.

The University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. However, the task you will learn presents no foreseeable health risks. In the event an injury is suffered due to your participation in the study, or if you have questions at any time about the study or the procedures, please contact Dr. Jeffrey T. Fairbrother, via the telephone numbers or email addresses indicated on this consent form. 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 (please print): ____

Participant’s signature: ___________________________________ Date: ___________

Investigator’s signature: __________________________________ Date: ___________

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Appendix B

Soccer Throw In Study Questionnaire

1. How competent do you feel you are at the soccer throw-in task?

1 2 3 4 5 6 7

2. How certain are you that you can score 3/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

3. How certain are you that you can score 4/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

4. How certain are you that you can score 5/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

5. How certain are you that you can score 6/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

6. How certain are you that you can score 7/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

7. How certain are you that you can score 8/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

8. How certain are you that you can score 9/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

9. How certain are you that you can score 10/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

10. How certain are you that you can score 11/11 on the form score?

0 10 20 30 40 50 60 70 80 90 100

Appendix C

Post-Experiment Questionnaire

1. How competent do you think you are at the soccer throw-in?

1	2	3	4	5	6	7
Very Incompetent			Neutral			Very Competent

2. How do you feel your current skill in this task compares to when you first started the experiment?

1	2	3	4	5	6	7
Much Lower			Same			Much Higher

3. To what extent were you concerned with throwing with proper form?

1	2	3	4	5	6	7
Not at all			Somewhat			Very much so

4. To what extent were you concerned with throwing accurately?

1	2	3	4	5	6	7
Not at all			Somewhat			Very much so

5. For improving your form, how useful was it when the researcher told you what you did correctly?

1	2	3	4	5	6	7
Not helpful at all			Neutral			Very helpful

6. For improving your form, how useful was it when the researcher told you what you did incorrectly?

1	2	3	4	5	6	7
Not helpful at all			Neutral			Very helpful

7. How did the feedback you received from the researcher affect your confidence about performing the task?

1	2	3	4	5	6	7
Greatly decreased confidence			No effect			Greatly increased confidence

8. How did the feedback you received from the researcher affect your motivation to learn the task?

1	2	3	4	5	6	7
Greatly decreased motivation			No effect			Greatly increased motivation

9. How did the feedback you received from the researcher affect your level of enjoyment in practicing the task?

1	2	3	4	5	6	7
Greatly decreased enjoyment			No effect			Greatly increased enjoyment

10. Is there a way the feedback the researcher gave you could have been more helpful?

11. When you think about learning the task, what challenges stood out to you?

12. What was your impression of the model used in the demonstration?

13. Is there anything else that you think is important for me to know?

Appendix D

Responses to Open-Ended Items on Post-Experiment Questionnaire

9. Is there a way the feedback the researcher gave you could have been more helpful

101- Nope, very well delivered feedback- kind & constructive

102- No, but I would have liked to see my throws on the computer. That was not possible in this experiment though.

103- Seeing the video or knowing more than one thing to work on

104- none

105- no, I felt like giving one thing to fix at a time was the most helpful

106- provide more than 1 thing I did wrong, or telling me I fixed what I did wrong last time. Or letting me watch the video

107- not necessarily, it was just frustrating to always have a flaw in my form

108- since I made the same mistake multiple of times, he could have told what I should do to perfect my throw

109- it was hard to only get the one prompt or piece of feedback without engaging in discussion or asking follow-up questions. If I could have talked it out I think my confidence and motivation would have increased more.

110- Instead of one tip per throw give a couple things consistently wrong and let the participant know to work on these

111- no they were exact with each thing I was doing incorrectly and helped me to improve my throw

113- the verbal feedback was fine. I think it would've helped if I could have seen myself performing the incorrect form on video

201- Given me different kinds of feedback. Positive and negative. Different corrections than the same one over and over.

202- Yes, if the researcher would have given different feedback it would have helped let me know what to improve on

203- When learning a task, I need negative criticism in order to correct learn how to perform. I didn't know what I needed to work on

204- Things I was doing wrong and needed to improve on

205- Having more feedback would have possibly improved my ability

206- Tell me what I did wrong to fix my form

208- Telling what I did wrong instead of right

209- I think, for me, that feedback on an aspect that I did not perform correctly would have been more helpful so I could know what to alter in the throwing task

210- It might have been helpful if the researcher told me which cues I was close to getting right

211- It discouraged me to only hear one thing I did correctly each time and that only two form related things were discussed. The above made me try to focus on other parts of form but I never knew if/when I had them correct

212- Telling what did wrong and right, more specific

214- If the feedback had varied

301- Sure, this being more of a new experience for me, I think some feedback could have provided more technical information. For example, I consistently was informed that the ball was not directly over my head. However, I could not recognize how I needed to adjust it. I.e. left, right

302- Told me more detailed as to how exactly the form was incorrect, or maybe a tip to improve the aspects I was missing

303- In my opinion, including the comparison about this time and the past time, good and bad, will be useful to me

304- No

305- He only gave me one positive thing and one negative thing. It would've helped to hear more of both for each throw

306- Go through all 11 things and said which ones I was doing correct and wrong each turn; but that definitely would have been time consuming!

307- He could have provided more tips on how to correct my form instead of only telling me what I did wrong

308- The researcher only told me one thing I was doing right the whole time. Other feedback on things I was doing right would have been helpful

309- If he would have told me how many steps of the task I got correct

310- No, it was fine. I liked hearing what I did good and bad

311- Knowing if the one thing you did wrong was the only thing or if you did multiple things wrong

312- I think receiving different feedback on what I did correctly would have been helfpul

10. When you think about learning the task, what challenges stood out to you?

101- achieving all 11 objectives each throw

102- I always released the ball slightly to the right and never completely straight over my head.

103- having about 6 form thoughts during the throw

104- I have bad aim so hitting the target was a challenge, as well as having all 11 form tips to think about

105- having to think about all 11 of the techniques we went over and applying them to each throw

106- not being able to see what I was doing wrong

107- getting all 11 steps to happen correctly on the same throw

108- to have a perfect throw and be accurate every time.

109- not being able to talk more thoroughly about what needed to be altered to improve form. I knew what I needed to fix in general but more specific feedback would have been great, especially when it was the same feedback over and over. I got frustrated with this.

110- following all 11 steps. The follow through and having the ball not spin were the most difficult to remember/complete.

111- trying to remember each item they were looking for in the throw

113- when I received feedback about one aspect of the throw, I tried to focus on that during my next throw, but then I wasn't focusing on other aspects to the same extent.

201- Proper technique

202- I couldn't tell if I was performing the task like the guy in the video. Curving my body in the shape of a "C" seemed like a challenge to me.

203- Getting the proper curve in my spine in the throw

204- Know if I was doing the form correctly or not

205- The speed we went through the learning material. Less feedback on form

206- Accuracy and proper form

208- Consistency

209- Only being presented to the eleven things once. After a few throws I forgot exactly what was considered proper form

210- Continuing with the task without knowing exactly what I needed to improve upon was challenging

211- My trunk mobility/leaning back. Trying to focus on and get all 11 proper form techniques correct

212- Only getting the rules and directions once

214- The nuanced motions (such as curvature of the back) that one doesn't see or easily integrate into movement. Also, the timing of the steps of the throw-in motion

301- Hearing the feedback and trying to visualize and perceive what exactly I was doing correctly

302- Not knowing the task very well. Also I wanted to be able to get feedback while watching the video of my throw in

303- The power control above my both arm in one time

304- Making sure my form was correct

305- Holding the ball directly over my head

306- Do all 11 things at the same time

307- Making sure that my back was in the "C position" when I threw the ball was the most obvious challenge for me

308- It was difficult to keep the ball straight when bringing it behind the head

309- Challenges with landing my foot before arm flexion; no circle form in my back when my foot was planted

310- to have a good form and accuracy

311- Doing all 11 things at once, trying to remember them all

312- A challenge was correcting a mistake without compromising what I've been doing correctly

11. What was your impression of the model used in the demonstration?

101- very clear, concise, and easy to learn from

102- he displayed good form. Textbook technique.

103- it was useful to see the motion since I don't watch soccer

104- the model was simple yet seemed very effective

105- I thought her form was really noticeable and it really helped to understand exactly what the throw should look like

106- the model was helpful but being able to watch it more than once would have been better

107- he had good form

108- not really impressed, it looked easy

109- it was good to see a demonstration. I think seeing the 11 points of good form before and after the demonstration would have been helpful.

110- showed me good form of what I should look like when I was throwing. It was in the back of my mind and I was trying to mimic him.

111- that he did the throw correctly and showed me how it should look

113- I thought it was helpful, so I could visualize how to correctly perform the task.

201- Indifferent

202- The model made the task look easy

203- It was helpful

204- Good, helpful

205- He had good form, possibly has a background in soccer

206- Well done and very well thought out and helpfuk

208- Had a lot of practice; good form

209- It was a good model. I enjoyed how not only was there words describing what I should do but also an accurate picture representing proper form

210- I did not like the fact that I wasn’t told how my form could improve

211- Long arms/lengthy- could help him with the arched back. Bigger hands than mine allowed him to hold the ball easier/have more control

212- good- I liked the visuals

214- Capable

301- The model seemed quite symmetrical, but the backdrop view of the doors was slightly distracting

302- There was a lot of information. It was difficult to remember all eleven of the cues

303- Not so much. I correct my movement by the practice and the feedback (good, wrong) from the researcher

304- he must have played soccer before

305- They were competent in the soccer throw

306- Very good; helped me to understand what I needed to do

307- I felt that the model had prior experience with throwing the soccer ball

308- The model was skilled at performing the task

309- It was ok, but I should have watched it a few more times

310- that he did the throw perfect

311- It was good; easy to understand

312- The model looked like he knew what he was doing

12. Is there anything else that you think is important for me to know?

101- Nope!

102- no, hope your research goes well!

103- not really, verbal follow-up: would have been helpful to know if he fixed the thing that was wrong in the previous throw.

104- no response

105- nope

106- my back hurts now

107- I feel like I may have learned better by watching someone do it in person

108- I cannot explain the reason why I throw slightly to the right of my head

109- my self-talk was a little bit all over the place and the first round of 30 trials was long and I lost focus.

110- nothing.

111- no.

113- no.

201- Other than #9, no

202- N/A

203- Nope

204- N/A

205- No

206- No

208- No

209- No, thanks

210- N/A

211- On the second day, it was hard to remember all 11 forms – for throwing and answering questions

212- N/A

214- The feedback motivated me to learn the task in-so-far-as I wanted feedback that let me know I was performing other aspects of the motion correctly

301- Sure, I felt that the first step was too short and that by taking a natural step I may be stepping out of the frame of the camera

302- After a few throws of not improving much in form I just started focusing on the target. I figured if I couldn't get the form down at least I would be accurate

303- The light is too bright

304- No

305- No

306- Good luck with your study!

307- None

308- Not really. Explanations and demonstrations were fairly straight forward and feedback was clear

309- First day of trial, I had moderate back and abdominal muscle soreness from a morning yoga class

310- No

311- Nope

312- I've partially dislocated my right shoulder which may have affected my form

Vita

Kevin Becker was born on May 1, 1984 in Rochester, MN. Prior to attending the University of Tennessee, he completed a Bachelor of Science degree in Physical Education and Health Education at the University of Wisconsin- La Crosse, and a Master of Science degree in Kinesiology: Psychology of Sport and Physical Activity from Illinois State University. In May 2014, he received his Doctor of Philosophy degree in Kinesiology with a specialization in Sport Psychology and Motor Behavior.