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The Effects of Attentional Focus Cues and Feedback On Motor Skill Learning In Children

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DEDICATION

To my husband and best friend, James: There are no words to express how important you have been throughout this process. Thank you for your unconditional love and support as well as all the sacrifices you have made that have allowed me to pursue my professional goals. I hope I can make it up to you one day.

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ABSTRACT

Considerable research over the past decade has produced overwhelming evidence to support the motor learning advantage associated with an external focus of attention. Despite this robust finding, very few studies have investigated attentional focus effects with children. This is surprising given that considerable information processing differences exist between children and adults that have the potential to influence motor performance and learning. Therefore, two studies were conducted to determine the effect of attentional focus cues and feedback on motor learning in children. In the first study, 42 children ages 9 to 11 were recruited from an afterschool program and randomly assigned to one of three gender-stratified groups: (1) control, (2) internal focus, or (3) external focus. Following initial instructions and task demonstration, participants performed 100 modified free throws over two days while receiving additional cues respective to their attentional focus condition and returned approximately 48 hours later to perform 20 additional free throws. Results revealed no significant learning differences between groups. Although responses to retrospective verbal reports suggest that treatment manipulations were somewhat effective, aiming cues used by the control group and goal directed content used across groups could have potentially negated some treatment effects. In the second study, an additional 28 children ages 9-11 were recruited from the same afterschool program and randomly assigned to one of two gender-stratified groups: (1) internal focus feedback or (2) external focus feedback. The task and procedure were identical to the previous study with one exception. In lieu of attentional focus cues,

participants received one of four feedback statements respective to their attentional focus condition following every third trial during practice. Results indicated a significant learning advantage for participants receiving external focus feedback. When compared to the first study, possible explanations for these findings include the external focus group's greater reported use of feedback and aiming content and the additional benefits of feedback over cues (e.g., frequency). Future research should continue to expand this body of literature to other tasks and age groups as well as investigate explanations regarding potential commonalities between mechanisms underlying aiming content (e.g., quiet eye) and attentional focus.

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CHAPTER 1:

INTRODUCTION AND REVIEW OF LITERATURE

Some level of attention is required for learning and performing complex motor skills. Given the limits on attentional resources early in learning, it is imperative that researchers determine the types of attentional foci that have the most influential effect on learning. Although counterintuitive, research has shown that participants given instruction about skill execution were less effective during practice (Wulf & Weigelt, 1997) and transfer (Hodges & Lee, 1999) than those given no instruction at all. In addition, "just do it" strategies (Singer, 1988) and implicit learning approaches (Masters, 1992) have proved problematic. In response, Wulf (2007) offered an alternative approach. Through a combination of anecdotal and experimental evidence, she has shown that an external focus of attention, whereby one directs attention to the effects of the movement, is more beneficial than adopting an internal focus of attention, whereby one directs attention to the movements (see Table 1.1 for examples). For example, participants in a study by Wulf, McNevin, and Shea (2001) balanced on a stabilometer while adopting either an internal (keep feet horizontal) or external (keep markers horizontal) attentional focus. They found that participants who adopted an external focus had less postural sway in retention than those who adopted an internal focus.

In addition to balance tasks, the advantage of an external focus has been replicated for learning golf pitches (Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007), basketball free throws (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002;

Zachry, Wulf, Mercer, & Bezodis, 2005), dart throws (Marchant, Clough, & Crawshaw, 2007; Marchant, Clough, Crawshaw, & Levy, 2009), and volleyball serves and soccer passes (Wulf, McConnel, Gärtner, & Schwarz, 2002). An external focus has also proved advantageous for improving vertical jump height (Wulf & Dufek, 2009; Wulf, Zachry, Granados, & Dufek, 2007), swimming speed (Freudheim, Wulf, Madureira, Pasetto, & Correa, 2010; Stoate & Wulf, 2011) agility running speed (Porter, Nolan, Ostrowski, & Wulf, 2010), and muscular endurance (Marchant, Greig, Bullough, & Hitchen, 2011).

Despite the extant literature on the beneficial effects of adopting an external focus of attention (see Wulf, 2007 for a review), very few studies have investigated attentional focus effects with children. Of those that have, the findings have been mixed (Emanuel, Jarus, & Bart, 2008; Thorn, 2006; Wulf, Chiviacowsky, Schiller, & Avila, 2010). There are considerable information processing differences between children and adults that have the potential to influence motor performance and learning. These include age related improvements in processing speed (Gallagher & Thomas, 1980; Thomas, Gallagher, & Purvis, 1981; Thomas, Mitchell, & Solmon, 1979), labeling of movements (Winther & Thomas, 1981), rehearsal strategy usage (Gallagher & Thomas, 1984; Thomas, Thomas, Lee, Testerman, & Ashy, 1983), memory organization (Gallagher & Thomas, 1986), and selective attention (Ross, 1978).

There is already some evidence to suggest that children and adults are differentially affected by attentional focus instructions (Emanuel et al., 2008) as well as by reduced feedback (Goh, Kantak, & Sullivan, 2012; Sullivan, Kantak, & Burtner, 2008) and contextual interference (Hall & Boyle, 1993; Jarus & Goverover, 1999). If a major goal of motor learning research is to inform practice in physical education and sport settings involving children and adolescents, it is premature to generalize from adult populations regardless of how robust the findings may be. Instead, it is vital that researchers attempt to replicate these findings in relevant populations for which they will be applied. Therefore, the purpose of this research project is to determine the effect of attentional focus instructions and feedback on motor learning in children.

The following literature review opens with a description and supporting evidence of the major theoretical framework used to explain the advantage of an external focus of attention for performance and learning. The subsequent section provides a comprehensive review of research on attentional focus instructions and feedback, respectively. Finally, a major limitation of the current literature is discussed along with an explanation of how the two studies of this research project help to advance our current understanding of the role attentional focus plays in children's motor skill learning.

Theoretical Framework

The major theoretical framework used to explain the effects of attentional focus on motor learning and performance is the constrained action hypothesis (e.g., McNevin, Shea, & Wulf, 2003; Wulf et al., 2001; Wulf, Shea, & Park, 2001). This hypothesis (CAH) was developed as an alternative to the original theoretical framework, common-coding theory (Prinz, 1990, 1997), which Wulf and Prinz (2001) argued was too abstract and did not make specific predictions relative to the differential effects of each attentional focus on learning. According to the CAH, focusing on the effects of one's movements (external focus) allows unconscious, reflexive control processes to govern the action. In contrast, focusing on one's movements (internal focus) disrupts this automatic control by constraining the motor system. Evidence to support this view comes from three areas:

attentional capacity, frequency of movement adjustments, and muscular activity. These are discussed next.

Attentional Capacity

According to the CAH, an external focus should result in a reduced attentional load due to automatic processing. A common method to examine the attentional resources occupied by a skill is the dual-task paradigm. Under this paradigm, participants perform a primary task simultaneously with another arbitrary task (e.g., responding to an auditory tone). The attentional demands of the primary task are inferred from the participant's performance on the secondary task (e.g., probe RT). That is, a short RT suggests that the primary task required little attentional resources. Wulf and colleagues (2001) used this dual-task paradigm to examine the effect of attentional focus on attentional capacity. Two groups of participants (internal and external) balanced on a stabilometer while simultaneously responding to an auditory stimulus as quickly as possible (i.e., probe RT). After two days of practice, the authors found that the external group had faster RTs on the secondary task than the internal group both during practice and on a retention test the next day. That is, the external group was able to respond to the auditory stimulus faster because there were more attentional resources available. This finding provides some preliminary support for the notion that an external focus promotes the use of automatic control processes during motor performance.

Another way to assess demands on attentional capacity is to measure performance on the primary task while performing a simultaneous secondary task. In one study (Totsika & Wulf, 2003), participants were assigned to either an internal or external group and practiced riding on a Pedalo. The next day, each group performed three transfer tests:

(1) speed pressure forward, (2) speed pressure backward, and (3) speed pressure forward while counting backward in 3's. The third transfer test was intended to increase the attentional demands of the task. The authors found that the external group had faster movement times than the internal group across all three transfer tests. These results appear to corroborate those of the probe RT experiment above. However, opposing evidence has also been found.

In a series of two experiments, Poolton, Maxwell, Masters, and Raab (2006) had two groups of participants practice a golf putting task using either an internal or external attentional focus. Attentional focus instructions in the first experiment were unequal (e.g., more internal than external) but was corrected in the second experiment (e.g., equal number of each). Following practice, retention and transfer tests were conducted in an A-B-A design. The retention test was identical to practice while the transfer test included the addition of a secondary task (counting tones). They found that when the secondary task was added (i.e., transfer), participants in the external group were more accurate in putting than those in the internal group; however, this effect was not maintained in the second experiment. In a similarly designed study, Maxwell and Masters (2002) also found no group difference for participants' wobble board performance while performing a secondary task (counting tones) during transfer. Given the mixed findings using this type of approach, there appears to be no clear consensus as be whether using an external focus decreases attentional demands during motor performance. Thus, future investigation is warranted.

Frequency of Movement Adjustments

Another source of evidence to support the CAH comes from the frequency of movement adjustments made during balance tasks, as analyzed by Fast Fourier Transformations. If automatic control processes are responsible for the control of movements under external focus, there should be high frequency adjustments made during the movement in response to perturbations relative to the environment or one's actions. Several balance studies (McNevin et al., 2003; Wulf, McNevin et al., 2001; Wulf, Shea et al., 2001) have provided evidence in support of this notion. In these studies, participants who balanced on a stabilometer while adopting an external focus of attention had higher frequency adjustments than those who adopted an internal focus. Higher response frequencies were also observed when participants used an external focus during supra-postural tasks (McNevin & Wulf, 2002; Wulf, Mercer, McNevin, & Guadagnoli, 2004).

Muscular Activity

A final line of evidence in support of the CAH addresses the effect of attentional focus at the neuromuscular level. If automatic control results from adopting an external focus, it stands to reason that there would be less "noise" in the motor system and, therefore, more efficient muscle use during the movement. Vance, Wulf, Töllner, McNevin, and Mercer (2004) investigated this notion by examining participants' muscle activity while performing a bicep curl using either an internal (biceps) or external (curl bar) focus of attention. They found that there was less muscular activity when participants used an external focus than when an internal focus was used. Similar findings were reported for studies using a basketball free throw (Zachry et al., 2005), vertical jump (Wulf, Dufek, Lozano, & Pettigrew, 2010), and dart throw (Lohse, Sherwood, & Healy, 2010). Interestingly, Marchant, Greig, and Scott (2008) found similar results with an elbow flexion task even with the addition of a control condition. That is, muscular activity was reduced using an external focus above and beyond what "naturally" occurs.

More recently, Wulf and Lewthwaite (2010) expanded on the CAH to address a potentially related cause for the facilitation or disruption of automatic movement control. Termed the self-invoking trigger, they posit that the mere mention of one's body parts or sensations (i.e., internal focus) is enough to trigger access to the self in the form of self-evaluation and self-regulation processes. These processes, unconscious or potentially conscious, are used to gain control over one's cognitions and affective responses. If these processes exceed the attentional capacity of the individual, automatic control may be disrupted resulting in motor performance degradation. Preliminary evidence provides some support for the self-invoking trigger (McKay, Wulf, & Lewthwaite, 2012); however, further research is needed.

Summarization of Studies

The following section provides a summary of the extant literature examining attentional focus effects on learning and performance. It is organized into two main parts: instructions and feedback. Each part provides a general introduction and follows with associated research.

Instructions

Instructors often pair a visual demonstration with verbal instructions when introducing a new motor skill to learners. These instructions serve to orient learners to the new skill, draw attention to the critical elements of skill execution, and highlight common errors they may encounter (Schmidt & Lee, 2005). Instructions are often reduced to a few concise words or phrases referred to in the pedagogy literature as verbal cues. According to Rink (2010), good cues are accurate, critical to the intended task, limited in number, and age and skill level appropriate. Verbal cues are thought to be effective for motor learning because they draw attention to appropriate sensory information, reduce the cognitive load needed to process information relevant to skill execution, and prepare appropriate muscles and motor programs for action (Landin, 1994).

Instructions and/or verbal cues can be used to evoke either an internal (movement related) or external (effect related) focus of attention. For example, a student learning a golf putt could be instructed to focus on the swing of their hands (internal) or the swing of the putter head (external). Previous research has consistently demonstrated a learning and performance advantage for adopting an external focus across a variety of motor skills. There is also evidence to suggest a preference for using an external focus after obtaining some practice with the skill. These findings are discussed next.

Effects on learning. The majority of early research on attentional focus instructions used balance tasks. In one of the first attentional focus studies, Wulf, Höß, and Prinz (1998, Experiment 2) had participants balance on a stabilometer using either an internal or external focus. Participants in the internal group were told to keep their feet the same height while participants in the external group were told to keep markers located on the platform the same height. After two days of practice, the external group had less postural sway in retention than the internal group. These findings were replicated in a similar study (Wulf, McNevin et al., 2001) even with the presence of a secondary probe RT task. Wulf, Weigelt, Poulter, and McNevin (2003, Experiment 1) also found a similar effect using a supra-postural task. In their experiment, participants balanced on a stabilometer while holding a tube containing a tennis ball. The internal group focused on keeping their hands horizontal while the external group focused on keeping the tube horizontal. After two days of practice, the external group had less postural sway in retention and transfer (no pole) than the internal group.

McNevin et al. (2003) extended the findings above by varying the distance of the external cue from the performer. In their study, one internal (feet) and three external (markers) focus groups practice balancing on a stabilometer over two days. The external groups differed in the placement of the markers they were instructed to focus on. The external near group focused on markers directly in front of their feet while the external far groups focused on markers that were either on the far outside or far inside of their feet. One day following practice, a retention test showed that the external groups had less postural sway than the internal group and, more interestingly, both external far groups had less postural sway than the external near group. This finding provides evidence to suggest that, for balance tasks, increasing the distance of the external focus from the participant increases the associated learning effect.

Along with internal and external focus conditions, some studies (Wulf et al., 1998, Experiment 1; Wulf et al., 2003, Experiment 2) have included a control group to more accurately determine the manner in which attentional focus affects learning. Wulf et al. (1998, Experiment 1) had participants learn a ski-simulator task in which the internal group focused on exerting force on their outer foot while the external group focused on exerting force on the outer wheels. They found a learning advantage for the external group over the internal and control groups, which did not differ from each other. Wulf et al. (2003, Experiment 2) found a similar effect in transfer for participants learning the supra-postural task from Experiment 1. These findings lend support to the notion that an external focus enhances learning rather than that an internal focus degrades learning. In addition to adding a control group, Wulf and McNevin (2003) also included another group designed to discourage participants from adopting an internal attentional focus. Participants learned to balance on a stabilometer using either an internal focus (keep feet horizontal), external focus (keep markers horizontal), shadowing (shadow story while balancing), or control condition. After two days of practice, they found that the external group had less postural sway in retention than all other groups. This suggests that preventing an internal focus does not produce the same learning benefit as adopting an external focus.

An early attempt to generalize the effect of attentional focus to a sport skill in a realistic setting was made by Wulf et al. (1999). Participants performed a golf pitch while focusing on either their mechanics (internal) or the pendulum-like motion of the club (external). The authors found that the external group was more accurate than the internal group both during practice and during a retention test one day later. A similar study was conducted with the addition of a control group (Wulf & Su, 2007, Experiment 1). Participants performed a golf pitch while focusing on either the swinging motion of their arms (internal), the pendulum-like motion of the club (external), or no attentional focus (control). After one day of practice, the external group was more accurate during retention than the internal and control groups. These findings provide support for the learning advantage of adopting an external focus for more realistic sport skills.

A different approach for manipulating attentional focus instructions was taken by Al-Abood et al. (2002). In their study, participants performed a pre-test of five free throws. They were then instructed to view a model performing a free throw while focusing on either the model's movement dynamics (internal) or the model's movement effects (external). They found that participants who focused on the model's movement effects had greater improvements in accuracy during a post-test than participants who focused on the model's movement dynamics.

Most studies have investigated attentional focus effects using outcome measures. However, Lawrence, Gottwald, Hardy, and Khan (2011) used a gymnastic routine in their study to determine whether attentional focus has an effect on movement form. Participants practiced the routine over two days while focusing on either their mechanics (internal relevant), facial muscles and facial expressions (internal irrelevant), the movement pathway and keeping even pressure (external), or no attentional focus (control). After a one week retention interval, the groups did not differ in technique scores on a retention and transfer test. This seems to suggest that the learning advantage of an external focus may be limited to skills in which outcome is of most importance.

Other researchers have examined the effect of attentional focus instructions on movement form using more objective measures, namely kinematic analysis. In one study, Zentgraf and Munzert (2009) had participants practice two-ball juggling while focusing on either their arms and hands (internal), the balls (external), or no attentional focus (control). Kinematic measures of elbow and ball height displacement were taken as well as error and success rate as measured by three raters blind to the study. While there were no differences between groups for error and success rate on a retention test two days later, the internal group had less elbow displacement than the external group and the external and control groups had less ball height discrepancy than the internal group. Their findings indicate that the learning advantage for specific aspects of movement form directly correspond with the type of attentional focus instructions used.

Southard (2011) took this design one step further by adding a control parameter to the attentional focus instructions and using a predominately outcome based skill. In his first experiment, participants practiced an overhand throw over six sessions under one of six focus conditions: (1) internal, (2) external, (3) velocity only (throwing the ball as fast as possible), (4) internal + velocity, (5) external + velocity, or (6) control. In additions to receiving instructions, participants in the internal and external groups were given feedback after every fifth trial respective to their attentional focus. Participants in the velocity groups also received feedback regarding their average throwing velocity from the previous five trials. Kinematic measures of elbow and wrist lag were recorded. Southard found that the velocity groups maintained positive elbow lag during practice over the other groups; however, the effect was not sustained during a retention test one week following practice.

In the second experiment, Southard (2011) repeated the same design from Experiment 1 but added an additional measure of accuracy. With regard to kinematics measures, he found identical results to that of the first experiment for both practice and retention. With regard to outcome, the velocity only group was more accurate during the first four practice sessions; however, the external + velocity group was more accurate during retention. The findings of these two experiments suggest that an emphasis on a control parameter, such as velocity, is more beneficial to movement form than adopting a specific attentional focus. However, these effects do not hold entirely true when movement outcome is a concern. In this case, it seems that velocity alone will not suffice unless paired with an external attentional focus.

Although an external focus has proved advantageous for learning a variety of motor skills, researchers became interested in determining if the type of external focus plays a role in the effectiveness of this attentional focus strategy. Wulf, McNevin, Fuchs, Ritter, and Toole (2000) conducted two experiments to examine this question. In the first experiment, participants practiced a tennis forehand while focusing on either the trajectory of the approaching ball (antecedent) or the anticipated ball arc and landing location on target (effect). They found that the effect group was more accurate than the antecedent group on a retention test the next day.

As a result of these findings, a second experiment (Wulf et al., 2000) was conducted to determine if the type of movement effect has an impact on learning. Participants in this experiment practiced a golf pitch while focusing on either the pendulum-like movement of the club (movement related) or the anticipated ball arc and landing location on the target (non-movement related). They found that the movement related group was more accurate than the non-movement related group during practice and a retention test the next day. In a similar study (Shafizadeh, McMorris, & Sproule, 2011), participants performed a golf putting task while either focusing on the target, the club swing, or a combination of both. After one day of practice in which feedback was given, the combined group (target and club swing) was more accurate in retention that the other two groups. Although the findings of Shafizadeh et al. suggest that a combination of movement and non-movement related foci are more beneficial than either one in isolation, these two studies used different golf skills. As a result, it is difficult to ascertain the generalizability of either finding to other skills without further investigation.

Effects on performance. Wulf, Töllner, and Shea (2007) conducted two experiments to determine the effect of attentional focus on balance performance using tasks of varying difficulty. In their first experiment, participants balanced on a force plate with and without a foam mat. For each task, participants performed one 15 s trial under each condition of internal, external, and no attentional focus. They found that participants balancing on the foam mat had less postural sway using the external focus than using none, but there were no differences when balancing on the force plate itself. Given the results of the first experiment, the authors concluded that the balance tasks may not have been challenging enough to get an overall effect. Therefore, they conducted a second study in which participants balanced on a rubber disk using two feet and then one foot only. As before, participants performed one 15 s trial under each condition for both tasks. They found for both tasks that participants had less postural sway using the external focus than when using the internal or none.

Marchant et al. (2007) used a different approach to examine the effect of attentional focus on performance of a sport skill. Three groups of participants practiced a dart throw to a target while using either an internal, external, or no attentional focus. Participants were measured on the accuracy of their throws and also filled out a questionnaire designed to assess their experience with using the respective task instructions. In regard to performance, the authors found that the external and control groups were more accurate than the internal group. Responses to the questionnaire items indicated that the control group rated their instructions less difficult than the internal group and less mentally demanding than both the internal and external groups. More interestingly, the internal and external groups appeared to be sensitive to how effective the instructions were to their performance. Specifically, the internal group indicated having less success using their instructions than the external group, which is in line with the difference in group accuracy scores.

More recent studies have addressed the effect of attentional focus on performance of fitness related tasks. In a series of studies, Wulf and colleagues investigated the effect of attentional focus on force production using a vertical jump task. In their first experiment, Wulf et al. (2007) measured jump-and-reach height of participants for five vertical jumps under each condition of internal, external, and no attentional focus. They found that participants jumped higher when using an external focus than when using an internal or no attentional focus. The second experiment included a measure of COM displacement in order to determine if the increased jump height was due to increased force production. The authors found that participants not only jumped higher but had greater COM displacement when using an external focus. Other studies found similar results for jump-and-reach height (Wulf & Dufek, 2009; Wulf et al., 2010) and COM displacement (Wulf & Dufek) when participants performed twice as many trials; however, a control condition was not included.

In a more recent study, Porter et al. (2010) examined the effect of attentional focus on agility performance. Participants were measured on movement time (MT) while performing an agility “L” run over three non-consecutive days. Each day participants performed five runs using either an internal, external, or no attentional focus. They found that participants had faster MTs when using an external focus than when using the internal or no attentional focus. An even more recent study examined the effects of attentional focus on muscular endurance. Marchant et al. (2011) had one set of participants perform an assisted bench press until failure under each condition of internal, external, and no attentional focus. The control condition was always performed first followed by the attentional focus conditions counterbalanced across participants. The authors found that participants performed more reps to failure when using the external focus than the internal. Another set of participants performed a bench press and free squat both at 75% 1-RM until failure using the same design. Similar to the results of the assisted bench press, participants performed more reps to failure when using the external focus than the internal or no attentional focus.

Although evidence seems to suggest that an external focus enhances the motor performance of novices across a variety of skills, it is unclear if this effect holds true for skilled or expert performers. As a result, several studies have attempted to investigate the performance effect on this population. For example, Wulf and Su (2007, Experiment 2) conducted a study with expert golfers to determine the effect of attentional focus on pitching accuracy. All participants performed 20 pitches to a target under each condition of internal, external, and no attentional focus counterbalanced across participants. The authors found that the golfers were more accurate when using the external focus than when using the internal or no attentional focus.

Bell and Hardy (2009) added an additional dimension by having skilled golfers practice pitching under neutral (3 blocks of 10) and anxiety (2 blocks of 10) conditions. Anxiety was successfully manipulated using social evaluation and financial incentive as evident by a significant increase in cognitive anxiety scores from the neutral to anxiety condition as measured by the Competitive State Anxiety Inventory-2 Revised. The golfers were assigned to either an internal, external-proximal (keep clubface square), external-distal (direction of ball flight), or no attentional focus. For both conditions, they found that both external groups were more accurate than the internal group with the external-distal group being the most accurate.

In addition to golfers, a series of recent studies (Freudheim et al., 2010; Stoate & Wulf, 2011) examined the effect of attentional focus on swimming speed of skilled swimmers. In their first experiment, Freudheim and colleagues divided the swimmers into two groups: arm stroke and leg kick. Participants performed a 16m front crawl stroke one time each under an internal and external focus respective to their group, counterbalanced across participants. The authors found that the external focus produced faster swimming speeds than the internal focus irrespective of group. These findings were followed up with a second experiment that included a control condition and only used the arm stroke attentional focus instructions. They also found that the external focus produced faster swimming speeds. In a similar study, Stoate and Wulf (2011) had skilled swimmers perform a front crawl stroke for three lengths of 25 yards one time under each condition of internal, external, and control counterbalanced across participants. They found that the external and control conditions produced faster swimming speeds than the internal.

The findings from golfers and swimmers appear to be in line with the predictions of the CAH in that an internal focus, whereby attention is directed at one's movements, would likely disrupt the automatic control processes associated with skilled performance. However, an external attentional focus has not always proved advantageous for skilled performers. For example, Wulf (2008) had world-class acrobats balance on a rubber disk positioned on top of a force plate for four 15s trials under each condition of internal, external, and control. Measures of postural sway and response frequencies were analyzed and compared across condition. She found that there were no differences across conditions for postural sway; however, the control condition produced higher response frequencies associated with automatic control. Wulf argues that these results may be due to a potential limit on the effectiveness of an external focus with expert performers.

In examining the impact of attentional focus on motor performance, some researchers have used an expert-novice approach to directly compare the effects across skill level. In one such study, Perkins-Ceccato, Passmore, and Lee (2003) had low and high skilled golfers practice a golf pitch from four target distances for 10 trials each using one attentional focus followed by another 4 blocks (target distances) of 10 trials using the other attentional focus. The attentional focus order was counterbalanced across participants. Average and variable error were calculated and compared across skill level. The authors found no differences for average error; however, low skilled golfers were more consistent when given internal instructions first while high skilled golfers were more consistent when given external instructions first. This provides some preliminary evidence that attentional focus effects may have differential effects based on the skill level of the performer. However, given the study design, these findings are limited to motor performance and do not provide any indication of learning effects.

In another study, Castaneda and Gray (2007) had low and high skilled baseball players practice a batting simulation task for 20 trials under each of five conditions counterbalanced across participants. Two of the conditions required participants to focus on skill execution by either judging the direction of their hand movements (internal) or the direction of the bat's movements (external) at the onset of an auditory tone. Two other conditions required participants to focus on environmental factors by either judging the flight path of the ball at the onset of the auditory tone (external) or the frequency of the auditory tone (irrelevant). A control condition was also incorporated. Mean temporal swing error was calculated and compared across skill level. For both skill levels, the authors found that the environmental/external condition produced less error than the environmental/irrelevant condition and the environmental conditions produced less error than the skill conditions. Interestingly, the skill/external condition produced less error than the skill/internal condition for the high skilled players while there were no differences for the low skilled players. This finding is contradictory to the predictions of Wulf et al. (2000) in which a movement-relevant external focus (i.e., skill/external) is more beneficial than a movement-irrelevant external focus (i.e., environmental/external). Castaneda and Gray argue that their results may be due to the increased attentional demands of the dual-task design, that their participants were not true novices as in other studies, or that the attentional focus effect may be different for baseball than other sports. However, this study is limited by the within participant design and only reflects motor performance outcomes associated with initial attentional focus usage. Consequently, this limits the generalizability of the findings to studies following a learning paradigm.

Attentional focus preference. A related area of interest has been participants' attentional focus preference and the associated effects on motor performance and learning. In a series of two experiments, Wulf, Shea et al. (2001) examined if there are individual differences in preference for adopting an internal or external attentional focus.

In the first experiment, participants alternated each trial between an internal and external focus while balancing on a stabilometer. The next day participants performed the same task using their preferred attentional focus condition. Participants' were evaluated on postural sway during practice on a retention test one day later. Although not significant, 10 of the 17 participants preferred an internal focus on the second practice day; however, there were no performance differences between preferred internal and external. Interestingly, in retention, only 5 of the 17 participants preferred an internal focus (marginally significant) and the preferred external participants had less postural sway than the preferred internal participants.

In their second experiment, Wulf, Shea et al. (2001) used a similar design in which participants balanced on a stabilometer using both attentional foci before specifying a preference to adopt during the second practice session. In contrast to Experiment 1, participants were free to alternate between an internal and external focus regardless of the trial. On the second day, participants only used their preferred attention focus. Participants' performance was scored similarly to experiment one during practice and a retention test one day later. Although significantly more participants (16 of 20) preferred an external focus following the second practice session, there were no group performance differences. However, in retention, participants preferring an external focus had less postural sway than the internal participants. The results from both experiments indicate that not only did adopting an external focus have a learning advantage, but participants also preferred an external focus after some practice.

Marchant et al. (2009) took the above design one step further by also examining the impact of previous attentional focus experience on motor performance. In their first experimental session, participants performed a dart throw while adopting one attentional focus for the first 20 trials and the other attentional focus during the next 20 trials. The attentional focus order was counterbalanced across participants. Participants were scored on accuracy and asked to indicate their attentional focus preference. Although no performance differences were found based on attentional focus, more participants preferred using the external focus. In the second experimental session, the same participants were randomly assigned to either an internal or external focus and performed an additional 40 trials of the dart throw. The authors found that the external group was more accurate than the internal group, and those within the external group who preferred an external focus were more accurate than those who preferred an internal focus. The findings from both sessions appear to be in line with those of Wulf, Shea et al. (2001).

An interesting addition to the second experimental session (Marchant et al., 2009) was a questionnaire completed by participants to assess their experience with using the attentional focus instructions. The results of the questionnaire items indicated that those who used an external focus attended more to the target and less to their arm and hand, found the instructions more difficult to follow, and were more distracted than those who used an internal focus. Although it is not surprising that an external focus would draw more attention toward movement effects (i.e., the target), it is interesting that participants found external instructions more difficult to use and were more distracted during task performance. The authors argue that these two findings may be due to the participants' lack of experience with the task.

Feedback

Another source of information available to learners about skill execution is feedback. Feedback is provided after skill execution and based upon the learner's prior performance. There are two main forms of feedback: knowledge of results (KR) and knowledge of performance (KP). KR is information available in the environment to the learner about the outcome of the movement. This might be inherent to the task in the way that a golfer can easily observe whether s/he missed a putt or augmented in the way that a golfer might learn from a spectator that he or she had holed a long chip onto a "hidden" green (Schmidt & Lee, 2005). KP, also termed kinematic feedback, is information about the quality of the movement. As with KR, this information can be available inherently, such as from the feel of the movement as it was executed, or be in an augmented form, such as feedback from a coach about how the movement was poor at its beginning.

The predominate form of feedback provided to learners by teachers and coaches is KP. Given the emphasis on movement form and technique, this form of feedback tends to naturally evoke an internal focus of attention. However, some researchers have attempted to manipulate the attentional focus of feedback statements to determine their potential impact on learning. These findings are discussed next.

An early study by Shea and Wulf (1999) examined the generalizability of external focus instructions to feedback. Four groups of participants practiced balancing on a stabilometer over two days. Two groups were instructed to focus on either keeping their feet the same height (internal) or keeping markers on the platform the same height (external). The other two groups received concurrent feedback via computer monitor that displayed a visual depiction of their horizontal deviation from neutral. Participants in the feedback/internal group were told the visual display represented their feet while participants in the feedback/external group were told it represented the markers. The authors found that both feedback groups had superior performance over the no feedback groups during practice and a retention test one day later. More notably, both external groups outperformed the internal groups during retention. This finding provides support for the generalized learning advantage of an external focus via feedback in addition to instructions.

In an attempt to determine the generalizability of attentional focus feedback for learning more realistic sport skills, Wulf et al. (2002) conducted two experiments using a volleyball serve and soccer pass. In the first experiment, novice and experienced volleyball players practiced a "tennis" serve during two sessions separated by a week. All participants were given one of four feedback statements following every fifth trial respective to their attentional focus condition, 2 (novice/experienced) X 2 (internal/external focus). The statements provided to the internal groups focused on mechanics while those provided to the external group were focused on movement effects relative to the ball. Participants were scored on accuracy and form (two raters) during practice and a retention test one week later. The authors found that the external groups were more accurate and had better form scores than the internal groups during practice and were more accurate than the internal groups during retention.

In their second experiment, Wulf et al. (2002) examined the interactive effects of feedback frequency and attentional focus on learning a lofted soccer pass. Participants with some soccer experience practiced the pass during a single session in which they received one of five feedback statements with either an internal or external focus every trial or every third trial, 2 (internal/external focus) X 2 (33%/100% feedback frequency). Participants were scored on accuracy during practice and a retention test one week later. The authors found that the external groups were more accurate than the internal groups and the 33% internal group was more accurate than the 100% internal group for both practice and retention. Interestingly, there were no differences between the two external groups for both practice and retention. This finding is disparate with previous research that supports the learning advantage of reduced feedback frequency. The authors argue that the beneficial effect of reduced feedback frequency may have more to do with the preponderance of internally focused feedback than the rate of delivery.

An area that had yet to be investigated is the potential interactive effect of gender and attentional focus. As a result, Wulf, Wächter, and Wortmann (2003) assigned 20 high school girls and 20 high school boys to either an internal or external condition. All participants practiced a soccer instep kick using a stationary ball to a target during a single session in which they received one of four feedback statements following every other trial. Participants were scored on accuracy during practice and a retention and transfer test (moving ball) the next day. The authors found no differences between groups during practice; however, the female internal group had larger accuracy decrements from retention to transfer than the female external group. As a result, these findings provide some evidence to suggest that females may benefit more from an external focus than males.

Limitation of the Literature

Despite the extensive literature and robust finding that an external attentional focus facilitates motor learning across a variety of skills, one major limitation still exists:

an overwhelming majority of these studies have been limited to adult populations. This is particularly problematic given that a prominent population of new movement learners is left out: children. If a major purpose of motor learning research is to inform movement practitioners (e.g., teachers, coaches), it is imperative that all populations of interest are included. Moreover, it is inappropriate to generalize results from adult populations to children regardless of how substantial the evidence. This is especially true given the information processing differences between adults and children that have the potential to differentially impact motor performance and learning. These are discussed next.

Information Processing Differences

A well-documented source of information processing differences between adults and children is processing speed. Specifically, as children age, they are able to process information more quickly. One way in which processing speed has been shown to improve with age is the ability to process the same amount of information in a shorter period of time. For example, Thomas and colleagues (1981) found that simple RT improved across age for 7-, 9-, 11-, 13-, and 20-year-olds. Gallagher and Thomas (1980) found a similar effect for the processing of feedback. In their study, post-KR intervals were varied for children (7- and 11-year-olds) and adults performing a linear slide movement. Specifically, participants received feedback after each trial with either a 3, 6, or 12 s post-KR interval. Overall, the 7-year-olds benefited the most from longer post-KR intervals in that there were significant performance improvements across the three intervals. With regard to age differences, the 7-year-olds were less accurate than both the 11-year-olds and adults at 3 s but only less accurate than the adults at 6 s. However, at the 12 s interval there were no differences in performance between the three age groups.

Thus, if given enough processing time, young children were able to perform as well as adults.

Another way in which processing speed has been shown to increase with age is the ability to process more information in the same amount of time. For example, Thomas and colleagues (1979, Experiment 2) varied the complexity of feedback to two different age groups to determine age related effects on performance due to processing capabilities. Participants consisted of second and fourth graders who performed a curvilinear positioning task followed by a fixed inter-response interval in which either no, general (direction error), or precise feedback (direction and magnitude error) was given. Although not significant, fourth graders who received precise feedback had improved performance above those who received general feedback. Interestingly, the second graders had the opposite effect; that is, those who received general feedback performed slightly better than those who received precise feedback. Although this result was also not significant, it suggests that an increased information load may be processed more efficiently with age.

Another major source of difference between adults and children lies in the functionality (i.e., control processes) of working memory. That is, as individuals age, they make better use of strategies and knowledge rather than simply acquiring a greater amount of memory storage. For example, young children do not typically make use of strategies to encode information for later recall. This was evident in a study by Winther and Thomas (1981) in which participants were asked to remember locations on an apparatus resembling a clock face for later recall. Of those not instructed to use specific labels for the locations, kindergartners did not report using any strategies (e.g., "I put on my thinking cap.") while most fifth graders reported using some type of image to label the location (e.g., "I used a pie graph.") and adults consistently reported using a clock face. Under these conditions, the adults were more accurate than the fifth graders who were more accurate than the kindergartners. However, when instructed to use a clock face to label the locations, the kindergartners and fifth graders were just as accurate as the fifth graders and adults, respectively, who used irrelevant images to label (i.e., animals).

Another control process that improves with age is rehearsal. Typically, spontaneous rehearsal does not begin until around the age of 7 or 8 and becomes more effective for performance with increased age (Thomas, 1984). For example, an experiment by Thomas and colleagues (1983, Experiment 1) found that third graders' recall of the distance an event occurred on a jogging route was superior to that of preschools. When asked how they remembered the distance, 30% of the third graders reported using a step-counting strategy while preschoolers reported no strategy use (e.g., *used brain*). In their follow-up experiment, 5-, 9-, and 12-year-olds were instructed to replicate a specific walking distance using either no strategy (i.e., control) or a step-counting strategy. When the control group was asked how they remembered the distance, almost all the 5-year-olds reported using no strategy (e.g., *tried hard to remember*) while 67% of 9-year-olds and 83% of 12-year-olds reported strategy usage (e.g., *counted steps*). These responses coincide with the performance data of the control group; that is, the 12-year-olds were more accurate than the 5- and 9-year-olds and the 9-year-olds were more accurate than the 5-year-olds. However, when instructed to use a step-counting strategy, there were no differences between the age groups.

There are also age related increases in the quality of rehearsal strategies. Children tend to use more passive forms of rehearsal (e.g., rote memorization) while adults use more active forms (e.g., rehearse current movement with previous movements). Gallagher and Thomas (1984) demonstrated this in their study in which children (5-, 7-, 11-year-olds) and adults (19-year-olds) performed a linear arm positioning task using either a mature, child-like, or subject-determined strategy. Using the mature strategy improved the performance of the young children (5- and 7-year-olds) while the child-like strategy somewhat decreased the performance of the older children (11-year-olds). Interestingly, the young children in the self-determined group spontaneously used the child-like strategy (e.g., rehearse current position) while the older children and adults used more mature forms (e.g., previous positions).

Memory organization is also a control process that has been shown to increase with age and consists of two aspects: grouping and recoding. Grouping involves combining incoming information in a meaningful way for storage in long-term memory while recoding involves taking pieces of previously stored information and combining them (Thomas, 1984). A study by Gallagher and Thomas (1986) examined developmental differences in memory organization of 5-, 7-, 11-, and 19-year-olds learning a series of eight movements. Some participants received training in an organizational strategy while others received no training or were presented with a prearranged organization (shortest to longest). After the training period, participants were instructed to reproduce a new series of eight movements presented in a random order. The results indicated that the untrained 5- and 7-year-olds were unable to organize the movement series during both training and transfer; however, the trained children did organize during training and to a slightly lesser extent during transfer. Interestingly, the 11-year-olds presented with the prearranged organization during training organized the new movement series more frequently than their 7-year-old counterparts even though both age groups organized similarly during training. This provides some evidence to suggest that children may not be able to transfer this type of strategy to a novel situation until sometime between the ages of 7 and 11.

Selective attention, the ability to attend to relevant stimuli in the environment, is a final information processing difference between adults and children that improves with age. According to Ross (1978), selective attention strategies progress in stages from over-exclusion to over-inclusion to selective attention. Prior to first grade (ages 5-6), children typically over-exclude in that they attend only to a single stimulus. As a result, the child is able to recall very little incidental information from the environment. From first grade to the beginning of adolescence (ages 5-12), over-inclusion tends to dominate; that is, children attend to most of the available environmental stimuli, both relevant and irrelevant, which results in higher recall of incidental information. During this phase, it is particularly important that children are provided with appropriate cues in order to direct their attention to the pertinent sensory information. The final stage, selective attention, is typically reached during early adolescence (ages 11-12) and is marked by the ability to attend to relevant stimuli while filtering out the irrelevant.

Given the information processing differences highlighted above, it is not surprising that there is some evidence to support the differential effects of motor learning variables on adults and children. The following section provides an overview.

Motor Learning Differences

The contextual interference effect, the motor learning advantage resulting from practice of multiple task variations, has been consistently demonstrated in adult populations. That is, adults learn motor skills better when they practice several variations of a skill randomly than when they practice the same variation repeatedly. However, the effect has not always been found for children. In one such study, Hall and Boyle (1993) assigned 24 fifth graders (ages 10-12) to either a random, blocked, or mixed group who practiced a modified shuffleboard task from three difference distances (25, 20, and 15 ft) to a pyramid target. Following practice, two transfer tasks were performed from two novel distances: 17 and 22 ft. They found no differences between groups at 17 ft; however, the blocked group was more accurate than the random and mixed groups at 22 ft. In another study, Jarus and Goverover (1999) assigned children in three different age groups (5-, 7-, and 11-years-old) to either a random, blocked, combined, or control group. Participants performed a beanbag throw to three different targets in acquisition and retention and an additional two targets in transfer. They found no differences between groups in retention for the 5- and 11-year-olds; however, the 7-year-olds in the blocked and combined groups were more accurate than those in the random group. Additionally, no differences were found between groups for any of the age groups for transfer. Although these two studies provide evidence to suggest that the contextual interference effect may not hold true for children, one could argue that the authors failed to directly compare the results to an adult sample.

Reduced feedback, the reduction in frequency of augmented feedback, is another variable in the literature that has consistently shown to be advantageous for motor learning in adult populations. That is, adults learn motor skills better when feedback is given intermittently than when it is given continuously. However, some recent evidence suggests this effect may not hold entirely true for children. In a recent study, Sullivan et al. (2008) directly compared adults and children on the effects of reduced feedback for learning a discrete, horizontal arm movement with specific spatio-temporal parameters. Participants in each age group were assigned to either a 100% feedback or reduced feedback (62% faded) group. Participants performed four 50 trial sessions in acquisition wherein the two reduced feedback groups received 100% feedback for session 1, 75% for session 2, 50% for session 3, and 25% for session 4. One day following practice, retention and reacquisition tests were performed. The authors found that adults with reduced feedback were more consistent in retention whereas children were more accurate and consistent with 100% feedback. In a recent follow up to their study, Goh et al. (2012) found that the reduced feedback only contributed to an increase in timing errors for the children's performance in retention while the movement pattern did not differ between groups. As a result, it appears that reduced feedback in children may have a more influential effect on parameter learning than pattern learning.

As reviewed previously (see Summarization of Studies), research has shown that an external focus of attention is advantageous for motor learning in adults; however, results have been mixed with children. In one study, Thorn (2006) had 9 to 12 year old children perform a balance task while adopting either an internal, external, or no attentional focus. After controlling for instructional focus usage via a questionnaire, she found that children who adopted an external focus had less postural sway in retention than those using an internal focus. However, Emanuel et al. (2008) found different results. In their study, 32 adults (ages 22-36 years) and 34 children (ages 8-9 years) performed a dart throwing task while adopting either an internal or external attentional focus. Although there were no differences between attentional focus conditions for either adults or children in retention, there was an interesting finding for a transfer test. Consistent with previous research, adults who adopted an external focus were more accurate than those that used an internal focus; however, the reverse was true for children. That is, children who adopted an internal focus were more accurate than those who used an external focus.

Additionally, Wulf et al. (2010) investigated the interactive effect of attentional focus feedback and feedback frequency in children learning a soccer throw-in. Forty-eight children (ages 10-12 years) were assigned to one of four groups: (1) external 100% feedback, (2) external 33% feedback, (3) internal 100% feedback, or (4) internal 33% feedback. Participants were scored on both accuracy and form. Although there were no differences between groups during an immediate and delayed retention test for both accuracy and form, the external 100% feedback group had better form scores (but not accuracy) than the other groups during an immediate and delayed transfer test. This result is contrary to the reduced feedback literature; however, the authors argue that providing feedback after every trial is only detrimental when statements are focused too much on the body. It is interesting to note that Goh et al. (2012) found the opposite trend in their study (i.e., parameter learning was improved by more frequent feedback while pattern learning was unaffected) especially since one could argue that the feedback given was external in nature (i.e., computer display of participant trajectory superimposed on target trajectory).

Statement of Purpose

Given the dearth of research and inconclusive findings with children, further investigation into the effects of attentional focus is needed. Therefore, the purpose of this research project is to determine the effect of attentional focus instructions (cues) and feedback on motor skill learning in children. Two separate studies were conducted. The first study (see Chapter 2) was designed to examine the effect of attentional focus cues on learning. Participants performed a complex sport skill using either an internal, external, or no attentional focus. It was hypothesized that the external group would outperform the internal focus and control groups on a retention test. The second study (see Chapter 3) was designed to examine the effect of attentional focus feedback on learning. Participants performed a complex sport skill while receiving either internal or external focus feedback statements. It was hypothesized that the external group would outperform the internal focus group on a retention test. Not only does this research project add to the current attentional focus literature, but it also provides valuable insight regarding appropriate application of motor learning variables to an understudied population.

Table 1.1

Examples of Internal and External Attentional Foci

Study	Task	Internal	External
Wulf, Höß, & Prinz (1998) – *Experiment 1*	Ski-simulator	Exert force on outer foot	Exert force on outer wheels
Wulf, McConnel, Gartner, & Schwarz (2002) – *Experiment 1*	Volleyball "tennis" serve	Snap your wrist while hitting the ball to produce a forward rotation of the ball.	Imagine holding a bowl in your hand and cupping the ball with it to produce a forward rotation of the ball.
Totsika & Wulf (2003)	Riding a pedalo	Push feet forward	Push platforms forward
Wulf, Wächter, & Wortmann (2003)	Soccer instep kick	Remember to kick the ball with the instep of your foot	Remember to kick the ball with the laces of your shoe
Vance, Wulf, Töllner, McNevin, & Mercer (2004)	Bicep curl	Concentrate on bicep muscles	Concentrate on curl bar
Wulf, Mercer, McNevin, & Guadagnoli (2004)	Balance on a stability disk holding a pole	Minimize movements of feet Hold hands still	Minimize movements of disk Hold pole still
Zachry, Wulf, Mercer, & Bezodis (2005)	Basketball free throw	Concentrate on the "snapping" motion of wrist during follow-through	Concentrate on the center of the rear of the hoop
Poolton, Maxwell, Masters, & Raab (2006) – *Experiment 1*	Golf putt	Focus on swing of hands	Focus on swing of putter head
Castaneda & Gray (2007)	Baseball batting simulation	Judge direction of hand movements	Judge direction of the bat's movement
Wulf & Su (2007)	Golf pitch	Focus on swinging motion of arms	Focus on pendulum-like motion of club
Marchant, Greig, & Scott (2008)	Elbow flexion (max force)	Focus upon the movement of the arm during the lift	Focus upon the movement of the crank handle during the lift
Marchant, Clough, Crawshaw, & Levy (2009)	Dart throwing	Focus on the movement of the arm as the dart is drawn back and during the throw, then focus on the release of the dart at the end of the throw	Focus on the center of the dartboard and toss the dart when focused
Freudheim, Wulf, Madureira, Pasetto, & Correa (2010)	Swimming – 16m front crawl stroke	Arm – Pull your hands back Leg – Push the instep down	Arm – Push the water back Leg – Push the water down
Porter, Nolan, Ostrowski, & Wulf (2010)	Agility "L" run	Running – Move your legs as rapidly as possible Turning – Plant your foot as firmly as possible	Running – Run toward the cone as rapidly as possible Turning – Push off the ground as forcefully as possible
Wulf, Dufek, Lozano, & Pettigrew (2010)	Vertical jump	Concentrate on the tips of your fingers	Concentrate on the rungs
Lawrence, Gottwald, Hardy, & Khan (2011)	Gymnastics routine	Focus on exerting equal force on feet, keeping arms straight, level with shoulders	Focus on movement pathway and exerting even pressure onto support surface
Marchant, Greig, Bullough, & Hitchen (2011)	Ex. 1 – assisted bench press Ex. 2 – bench press at 75% 1-RM Ex. 3 – free squat at 75% 1-RM	Ex. 1 & 2 – Focus on moving and exerting force with your arms Ex. 3 – Focus on moving and exerting force with your legs	Ex. 1, 2, & 3 – Focus on moving and exerting force through and against the barbell
Southard (2011)	Overhand throw	Rotate your left shoulder back; shift your weight toward your front leg; and accelerate your trunk first, then your shoulder, upper arm, lower arm, and hand.	Turn and face the wall; shift your weight toward the front mat; and use your entire body like a whip, like a horseman driving his horses.

Chapter 2: Journal Article 1

The Effect of Attentional Focus Cues on Motor Skill Learning in Children[1]

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Teachers and coaches often pair a visual demonstration with verbal instructions when introducing a new motor skill to learners. These instructions serve to orient learners to the new skill, draw attention to the critical elements of skill execution, and highlight common errors they may encounter (Schmidt & Lee, 2005). Instructions are often reduced to a few concise words or phrases referred to in the pedagogy literature as verbal cues. According to Rink (2010), good cues are accurate, critical to the intended task, limited in number, and age and skill level appropriate. One reason verbal cues are thought to be effective for motor learning is because they reduce the cognitive load needed to process information relevant to skill execution (Landin, 1994). This is especially important given the limits on attentional resources early in learning. Another reason they are thought to be effective is that they draw attention to appropriate sensory information. Given the abundance of sensory information available during motor skill learning, it is imperative that researchers determine the types of attentional foci that have the most influential effect on learning.

Although counterintuitive, research has shown that participants given instruction about skill execution were less effective during practice (Wulf & Weigelt, 1997) and transfer (Hodges & Lee, 1999) than those given no instruction at all. In addition, "just do it" strategies (Singer, 1988) and implicit learning approaches (Masters, 1992) have proved problematic. In response, Wulf (2007) offered an alternative approach. Through a combination of anecdotal and experimental evidence, she has shown that an external focus of attention, whereby one directs attention to the effects of the movement, is more beneficial than adopting an internal focus of attention, whereby one directs attention to the movements (see Table 1.1 for examples). Wulf and colleagues (e.g., McNevin, Shea,

& Wulf, 2003; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001) explain these findings using the constrained action hypothesis (CAH). According to the CAH, focusing on the effects of one's movements (external focus) allows unconscious, reflexive control processes to govern the action. In contrast, focusing on one's movements (internal focus) disrupts this automatic control by constraining the motor system.

Instructions and/or verbal cues can be used to evoke either an internal (movement related) or external (effect related) focus of attention. For example, a student learning a golf putt could be instructed to focus on the swing of their hands (internal) or the swing of the putter head (external). Previous research has consistently demonstrated a learning and performance advantage for participants using instructions with an external focus across a variety of motor skills. For example, Wulf et al. (2001) had participants balance on a stabilometer while adopting either an internal (keep feet horizontal) or external (keep markers horizontal) attentional focus. They found that participants who adopted an external focus had less postural sway in retention than those who adopted an internal focus.

In addition to balance tasks, the advantage of an external focus has been replicated for learning golf pitches (Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007), basketball free throws (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Zachry, Wulf, Mercer, & Bezodis, 2005), dart throws (Marchant, Clough, & Crawshaw, 2007; Marchant, Clough, Crawshaw, & Levy, 2009), and volleyball serves and soccer passes (Wulf, McConnel, Gärtner, & Schwarz, 2002). An external focus has also proved advantageous for improving vertical jump height (Wulf & Dufek, 2009; Wulf, Zachry, Granados, & Dufek, 2007), swimming speed (Freudheim, Wulf, Madureira, Pasetto, &

Correa, 2010; Stoate & Wulf, 2011) agility running speed (Porter, Nolan, Ostrowski, & Wulf, 2010), and muscular endurance (Marchant, Greig, Bullough, & Hitchen, 2011).

Despite the extensive literature and robust finding that an external attentional focus facilitates motor learning across a variety of skills (see Wulf, 2007 for a review), one major limitation still exists. An overwhelming majority of these studies have been limited to adult populations. Consequently, very little is known about attentional focus effects in children. Moreover, the few studies with children have produced mixed findings (Emanuel, Jarus, & Bart, 2008; Thorn, 2006). Despite this gap in the literature base, generalizations of the external focus advantage are still often made from adults to children. This is particularly problematic given the information processing differences between adults and children that have the potential to differentially impact motor performance and learning.

A well-documented source of these differences is processing speed. Specifically, as children age, they are able to process information more quickly. One way in which processing speed has been shown to improve with age is the ability to process the same amount of information in a shorter period of time. This has been demonstrated with age related improvements in simple RT (Thomas, Gallagher, & Purvis, 1981) and processing of feedback (Gallagher & Thomas, 1980). Processing speed has been shown to increase with age in that more information can be processed in the same amount of time. For example, Thomas, Mitchell, and Solmon (1979) found that fourth graders were able to use precise feedback more effectively than second graders to improve their performance on a curvilinear positioning task.

Another major source of difference between adults and children lies in the functionality (i.e., control processes) of working memory. That is, as individuals age, they make better use of strategies and knowledge rather than simply acquiring a greater amount of memory storage. For example, Winther and Thomas (1981) found age related improvements in encoding strategies when participants were asked to remember locations on an apparatus resembling a clock face. Very young children used their "thinking cap" while older children used a pie graph and adults a clock face. Similarly, age related improvements in the use (Thomas, Thomas, Lee, Testerman, & Ashy, 1983) and quality (Gallagher & Thomas, 1984) of rehearsal strategies have also been reported as well as for strategies relevant to improved memory organization (Gallagher & Thomas, 1986).

Selective attention, the ability to attend to relevant stimuli in the environment while filtering out anything irrelevant, is a final information processing difference between adults and children that improves with age. According to Ross (1978), selective attention strategies progress in stages from over-exclusion to over-inclusion to selective attention. Prior to first grade (ages 5-6), children typically over-exclude in that they attend only to a single stimulus. As a result, the child is able to recall very little incidental information from the environment. From first grade to the beginning of adolescence (ages 5-12), over-inclusion tends to dominate; that is, children attend to most of the available environmental stimuli, both relevant and irrelevant, which results in higher recall of incidental information. During this phase, it is particularly important that children are provided with appropriate cues in order to direct their attention to the pertinent sensory information. The final stage, selective attention, is typically reached during early adolescence (ages 11-12) and is marked by the ability to attend to relevant stimuli while filtering out the irrelevant.

Given the information processing differences highlighted above, it is not surprising that there is some evidence to support the differential effects of motor learning variables on adults and children. For example, contradictory evidence for the motor learning advantages associated with reduced feedback (Goh, Kantak, & Sullivan, 2012; Sullivan, Kantak, & Burtner, 2008) and contextual interference (Hall & Boyle, 1993; Jarus & Goverover, 1999) have been found in children. There is also some evidence to suggest that children and adults are differentially affected by attentional focus instructions (Emanuel et al., 2008). If a major goal of motor learning research is to inform practice in physical education and sport settings involving children and adolescents, it is premature to generalize from adult populations regardless of how robust the findings may be. Instead, it is vital that researchers attempt to replicate these findings in relevant populations for which they will be applied. Therefore, the purpose of this study is to determine the effect of attentional focus instructions on motor learning in children.

Method

Participants

Forty-two children between the ages of 9 and 11 years with no prior organized basketball experience (e.g., recreational leagues) were recruited from an afterschool program at elementary schools in the southeastern United States to volunteer for this study. Informed consent from legal guardians (see Appendix A) and assent from participants (see Appendix B) was obtained prior to the study in compliance with the university's Institutional Review Board.

Task, Apparatus, and Scoring

The task consisted of a basketball free throw using a 28.5" circumference basketball per AAU youth basketball equipment guidelines for this age range (Amateur Athletic Union, 2012). Participants shot from a 12 ft free throw line to a standard basketball goal set at a height of 9.5 ft in an indoor gymnasium. Free throw performance was scored based on a 3-point scale (Price, Gill, Etnier, & Kornatz, 2009). A score of 2 was given for a make, 1 for a near miss (ball hits rim), and 0 for a complete miss.

Procedure

Participants were randomly assigned to one of three gender stratified groups of equal size: (1) control, (2) internal focus instruction, or (3) external focus instruction. Testing was conducted individually over three days consisting of two identical practice sessions followed by a retention session approximately 48 hours later. Before beginning each practice session, all participants were provided with some initial instruction on how to perform a free throw. First, they viewed a video model of a correct free throw on a laptop computer followed by verbal instructions regarding correct free throw technique (adapted from Zachry et al., 2005). Next, participants viewed the video once more and received verbal cues as a reminder of the instructions. Finally, they were allowed five unscored warm-up trials to become familiar with the technique and equipment.

Following the warm-up trials, participants were given additional instructions respective to their attentional focus condition. Specifically, the internal focus group was instructed to focus on making an L-shape with their arm and resting the ball on their finger pads, while the external focus group was instructed to focus on balancing the ball on their hand like a waiter balances a tray. It was stressed to each participant the importance of adopting this attentional focus during performance of the task. The control groups received no additional instructions. Participants then performed 5 blocks of 10 practice trials with 1 minute breaks between blocks to prevent fatigue. Prior to each block of trials, participants in the attentional focus groups were reminded of their attentional focus instructions. At no point was feedback given regarding technique or performance outcome although participants received KR as a natural byproduct of vision.

On the following day, participants performed a second practice session similar in structure to the previous day. First, they received the same initial instructions on how to perform a free throw. Participants in the attentional focus groups were then reminded of their original attentional focus instructions and provided with an additional focus instruction. Specifically, the internal focus group was instructed to focus on snapping their wrist forward when releasing the ball, while the external focus group was instructed to focus on creating backspin on the ball during release. Again, the control group received no additional instructions. Participants then performed 5 blocks of 10 practice trials with 1 minute inter-block intervals. Reminders of the attentional focus instructions were provided before each block but no augmented feedback was given.

Approximately 48 hours following the second practice session, participants performed 2 blocks of 10 retention trials with a 1 minute break between blocks. No attentional focus reminders or feedback was given.

Manipulation Check

Following each day of practice and retention, participants were asked to respond to an open-ended question to serve as a manipulation check of the attentional focus manipulations as well as determine the types of “natural” thoughts experienced by the control group. Specifically, they were asked, “What were you thinking about today when you were practicing your free throw?" The format of the question was chosen to correspond with the recommendations of Ericsson and Simon (1993) for retrospective verbal reports in order to access traces of participants' working memory following task performance. Responses were recorded via audiotape verbatim; however, transcription of responses was summarized.

Data Analysis

Free throw performance. Alpha was set at .05 for all statistical analyses. Mean shooting score for each block in practice and retention was calculated. For the practice sessions, a 3 (Group) X 10 (Block) ANOVA with repeated measures on the last factor was conducted. For the retention session, a 3 (Group) X 2 (Block) ANOVA with repeated measures on the last factor was conducted.

Manipulation check. Responses to the manipulation check were analyzed using a verbal analysis method similar to Chi (1997). Each response was segmented into separate words and/or phrases representing distinct thought processes during performance.

Results

Free Throw Performance

All means and standard deviations are reported in Table C.1. The analyses revealed no significant interactions or main effects for both practice and retention ($p >$ .05). Figure 2.1 provides some indication of an interaction in retention in which the control group (M = .79, SD = .39) initially performs best in the first block followed by the internal focus group (M = .69, SD = .53) and the external focus group (M = .56, SD = .55) before all conditions converge during the second block. However, the means for each condition fell within the range of variability thus revealing no significant interaction.

Manipulation Check

After an examination of the verbal responses, two experimenters used a framework based on the instructional content presented to participants and other content commonly observed in novice learners (cf. Nielsen & McPherson, 2001) to develop a coding scheme for categorizing each response segment. Three major categories emerged from this framework: informational, irrelevant, and emotional content. Informational content was defined as information relevant to mediating task performance. This category was further divided into seven subcategories: (1) initial instructions, (2) internal focus cues, (3) external focus cues, (4) aiming, (5) goal, (6) other, and (7) evaluative. Irrelevant content was defined as information not relevant to mediating task performance. Emotional content was defined as feelings directed toward the task or a specific aspect of the task. This category was further divided into three subcategories: (1) positive, (2) negative, and (3) uncertain. See Table 2.1 for operational definitions and examples of all subcategories. Response segments were then coded independently by the two experimenters and adequate inter-rater reliability was obtained (95% agreement). See Appendix D for an example of one experimenter's coding sheet.

Informational content. Percentages of participants reporting informational content by subcategory across conditions for practice and retention are presented in Table 2.2. Since the main purpose of the verbal responses was to serve as a manipulation check for treatment effectiveness, we first evaluated the use of verbal cues by each group. The internal focus group did not report use of any external focus cues while approximately 21-29% reported using at least one internal focus cue throughout practice and retention. Likewise, the external focus group did not report use of any internal focus cues while approximately 21-29% reported using at least one external focus cue during the second practice day and retention. This provides some evidence that the treatment manipulations were effective to some extent for each attentional focus group.

As expected, the control group did not report using any internal or external focus cues. Instead, 14-29% reported using self-generated aiming cues throughout practice and retention. This is interesting given that only one participant in each treatment group on the first practice day reported using an aiming cue. Another interesting finding is that participants in each group rarely indicated using any information presented in the initial instructions (0-14%) despite being present before each day of practice. This is especially surprising for the control group since this was the only information provided to them on how to perform the task.

Additional types of information participants commonly reported using across conditions during practice and retention were goal and evaluative content. However, the majority of content in each of these subcategories was general in nature (e.g., thought I did better today) and very rarely directed at specific aspects of performance (e.g., [focus on L shape] because I realized it helped me more). With respect to goals, similar percentages were reported across practice and retention for the control (14-29%) and external focus (21-29%) groups while higher percentages were reported for the internal focus group (43-57%). With the exception of the first practice day for the internal focus group (7%), a somewhat similar trend was found for evaluative content in that similar percentages were found for the control (14-36%) and external focus (29-43%) groups while higher percentages were reported for the internal focus group (43-64%).

Finally, small percentages of each group (0-21%) reported using other information during practice and retention that did not fall into any of the former subcategories. Some of this content (e.g., staying balanced) is thought to have come from previous free throw instruction provided by a teacher, peer, or family member while several other statements appear to reflect strategies used to compensate for size and/or strength issues (e.g., make it go higher, jump forward).

Irrelevant content. Given that participants were novices, it is not surprising that similar percentages (7-29%) of each group reported using content during practice and retention completely irrelevant to mediating task performance (see Table 2.3). In fact, responses indicated that a few participants weren't thinking of anything at all (e.g., nothing) while others reported thoughts concerning daily activities (e.g., get to sleep early, homework for tonight) or other miscellaneous content (e.g., my feet are sweaty). Although not relevant to task performance, several of the responses were basketball related (e.g., one day might become pro player) and may provide some indication of participants' motivation for performing the task throughout practice and retention.

Emotional content. Also common in novices, participants in each group indicated some type of emotional processing during practice and retention (see Table 2.3). The control group reported higher percentages of positive emotional content (7-29%) than negative (7-14%) or uncertain (0%) while both the internal and external focus groups reported similar percentages of positive (7-14%; 0-14%) and negative (0-14%; 7-14%) emotional content and similar or slightly lower percentages of uncertain (7%; 0-7%). The positive emotional content generally indicated some level of enjoyment with the task or sport (e.g., it was fun, basketball is fun). Negative emotional content generally took on one of two forms, either unfavorable reactions toward the task or sport (e.g., scary because basketball is not my sport) or frustration with one's performance (e.g., mad it was bouncing off rim). Uncertain emotional content tended to reflect participants' insecurity with their performance potential or capabilities (e.g., how good will I get at it).

Discussion

The aim of this study was to expand the current literature base on the effectiveness of attentional focus cues to an understudied population—children. Participants aged 9-11 years practiced a modified basketball free throw over two days while adopting either an internal, external, or no attentional focus and returned approximately 48 hours later to perform a retention test. Based on the previous literature, it was hypothesized that the external focus group would outperform the control and internal focus groups during the retention test. In addition to being assessed on free throw performance, participants were also asked to respond to a retrospective verbal report following each day to serve as a manipulation check for treatment effectiveness. Responses were analyzed using a coding scheme based on informational content presented directly to, or generated by participants as well as content typical of novice performers. To our knowledge, we are the first to use this type of verbal analysis method while examining attentional focus effects on learning.

Results from free throw performance scores showed no significant differences between groups during retention, thus not supporting predictions from adult populations. In fact, upon examination of mean performance across practice and retention, the control group had the highest performance scores followed by the internal focus and external focus groups, respectively. As compared to previous research with children, the results of the current study support those of Emanuel et al. (2008) in which no external focus advantage was found for children learning a dart throwing task. However, they do not support those of Thorn (2006) who found an external focus advantage for children learning a balance task. A potential explanation for the difference in findings is the type of motor task used. Ballistic aiming tasks (e.g., dart throw, free throw), as compared to balance tasks, tend to rely predominately on visual information during performance. Combined with children's over-inclusion of sensory information prior to adolescence (Ross, 1978), attentional cues may not be as influential for learning these types of tasks. However, this is a preliminary interpretation that must be approached cautiously given the very small sample of studies available. Thus, future research is needed to determine if and how the type of task impacts the effectiveness of attentional focus cues for children learning new motor skills.

Another potential explanation for the lack of differences between groups in the current study could be that the treatment groups were not using their respective attentional focus cues. However, participant responses to the manipulation check regarding cue use were only directed at their respective attentional focus. That is, the internal focus group only reporting using internal focus cues and vice versa. Even so, only a relatively small percentage (0-29%) of participants in each group reporting using at least one of their attentional focus cues during both practice days and retention. A potential explanation for this small percentage is that participants were not accessing the attentional focus cues to the level of working memory. Since the manipulation check was given at the end of each practice and retention day, it may be that only the information processed during the last set of trials, or a summary of the information processed across trials was available in working memory. To get a more accurate representation of thoughts throughout practice, it may have been beneficial to include the manipulation check after each block of trials. However, the researchers wanted to avoid unnecessary influences to participants' behavior by drawing additional attention to their thoughts.

Participants may also not have been able to process the cues to the level of working memory due to some of the cognitive processing differences between adults and children. Previous research has shown that older children, a similar population to the current study, do not use encoding (Winther & Thomas, 1981) and rehearsal strategies (Gallagher & Thomas, 1984; Thomas et al., 1983) as effectively as adults without some type of training. Consequently, participants in the current study may not have utilized effective encoding and/or rehearsal strategies for the attentional focus cues making them difficult to retrieve for later use and/or harder to keep available in working memory throughout practice and retention. These processing differences may also help explain why the treatment groups rarely (0-7%) reported using any of the initial instructions during practice and retention.

The lack of differences between groups could also be due to treatment interference from participants' use of other informational content during performance. One type of informational content observed in the control group, but almost never in the treatment groups, is aiming. In fact, participants in the control group reported using aiming cues at a similar frequency to the treatment groups' attentional focus cues. This seems to indicate that in the absence of attentional cues children tend to use aiming as a "natural" focus while performing free throws. Although not entirely surprising given the visual nature of the task, this focus on aiming may help explain the lack of group differences in practice and retention. Quiet eye, a final fixation on a specific object or location, is commonly associated with highly skilled performance across a variety of aiming tasks (see Vickers, 2007 for a review). The effectiveness of quiet eye is explained by the location-suppression hypothesis (Vickers, 1996), which shares some commonalities with the CAH to explain the advantage of an external attentional focus. According to the hypothesis, an individual's final fixation on a location (e.g., hoop) allows the neural system to organize the aiming action. The location is then followed by a brief period of suppression in which the visual system is occluded during initiation of the action to prevent additional visual input from disrupting the aiming commands. Since aiming cues were reported being used almost solely by the control group, they may have benefitted in a similar way to the external focus group. However, without further research, it is impossible to determine whether the mechanisms underlying these two variables act similarly for aiming tasks.

Another potential source of treatment interference may come from the goal and evaluative content reported by both the control and treatment groups. These types of informational content were general, goal-directed statements regarding a desired result (e.g., make a good shot) or the evaluation of progress toward a desired result (e.g., thought I did better today) that rarely included detailed information about how to achieve them. These types of responses are common in novices and reflect a lack of knowledge concerning specific aspects of how to perform an action (French & McPherson, 2004). Since the majority of goal and evaluative responses were directed at a movement outcome, it can be argued that they do not fit the criteria for an internal focus of attention. This is of particular note for the internal focus group since much larger percentages of goal (43-57%) and evaluative (7-64%) content were reported by participants than the internal focus cues (21-29%). Thus, participants' emphasis on this type of content may have interfered with the treatment manipulation and negated any potential performance differences between groups.

Finally, the absence of group differences may be due in part to participants' lack of motivation or engagement in the motor task. However, evidence from reported irrelevant and emotional content across groups to the manipulation check suggest otherwise. Several participant responses with irrelevant content were directed at future basketball plans or an interest in other skills they might learn. For example, a participant in the control group expressed a desire to play a basketball game with his brother and friends and a participant in the internal focus group wanted to know if she was going to learn anything else. Participant motivation was also evident from the positive emotional content reported in that the majority of responses referenced basketball or the task as "fun". Interestingly, some participants' negative emotional content was directed at disappointment with their own performance thus conveying a level of engagement in the task. For example, a participant in the internal focus group expressed being mad because the ball kept bouncing off the rim. Likewise, a participant in the external focus group indicated being sad because she only got one successful basket. Participants' uncertain emotional content paints a similar picture in that most statements were directed at a concern for how well they were going to perform the task during a particular day.

The current study is not without its limitations. First, data collection was conducted in a school setting. Although this type of location does increase the ecological validity, it does limit the amount of experimental control. We were able to prevent or reduce several issues commonly experienced in schools by using an afterschool program. However, one problem we were unable to avoid occurred when other activities were being conducted in the gym or multipurpose room during data collection. While most facilities were large enough to accommodate shared usage, participants were often distracted or indicated concern with having to practice in front of their peers. This could have resulted in reduced performance due to loss of focus or increased levels of anxiety.

Another limitation of this study concerns participant variances in size and strength commonly observed during this age range due to differences in maturational timing (Haywood & Getchell, 2009). Although body scaling would have been ideal, it wasn't feasible to make continuous adjustments to the goal height and free throw distance based on the height of each participant. As a result, some participants may have been at a disadvantage. This is reflected in some of the performance scores that had an overall mean of zero as well as some of the other informational content reported by participants (e.g., make the ball go higher, jump forward). However, these were rare and spread rather evenly across groups thus most likely not creating an advantage or disadvantage for any one group.

In conclusion, this study adds to the limited research examining the effect of attentional focus cues on motor skill learning in children. Despite finding no significant differences between groups, responses to the retrospective verbal report suggests that the treatment manipulations were somewhat effective and participants were sufficiently motivated and/or engaged in the task. However, aiming cues used by the control group and goal directed content used across groups could have potentially negated some of the treatment effects. Thus, future research should continue to expand this research to other ages, tasks, and performance contexts as well as examine the types of thought processes experienced by participants during task performance. In addition, further investigation into explanations for the lack of group differences exhibited by this age group (e.g., cognitive processing, quiet eye) may help to provide additional insight into the mechanisms underlying the effects of attentional focus on motor learning and performance.

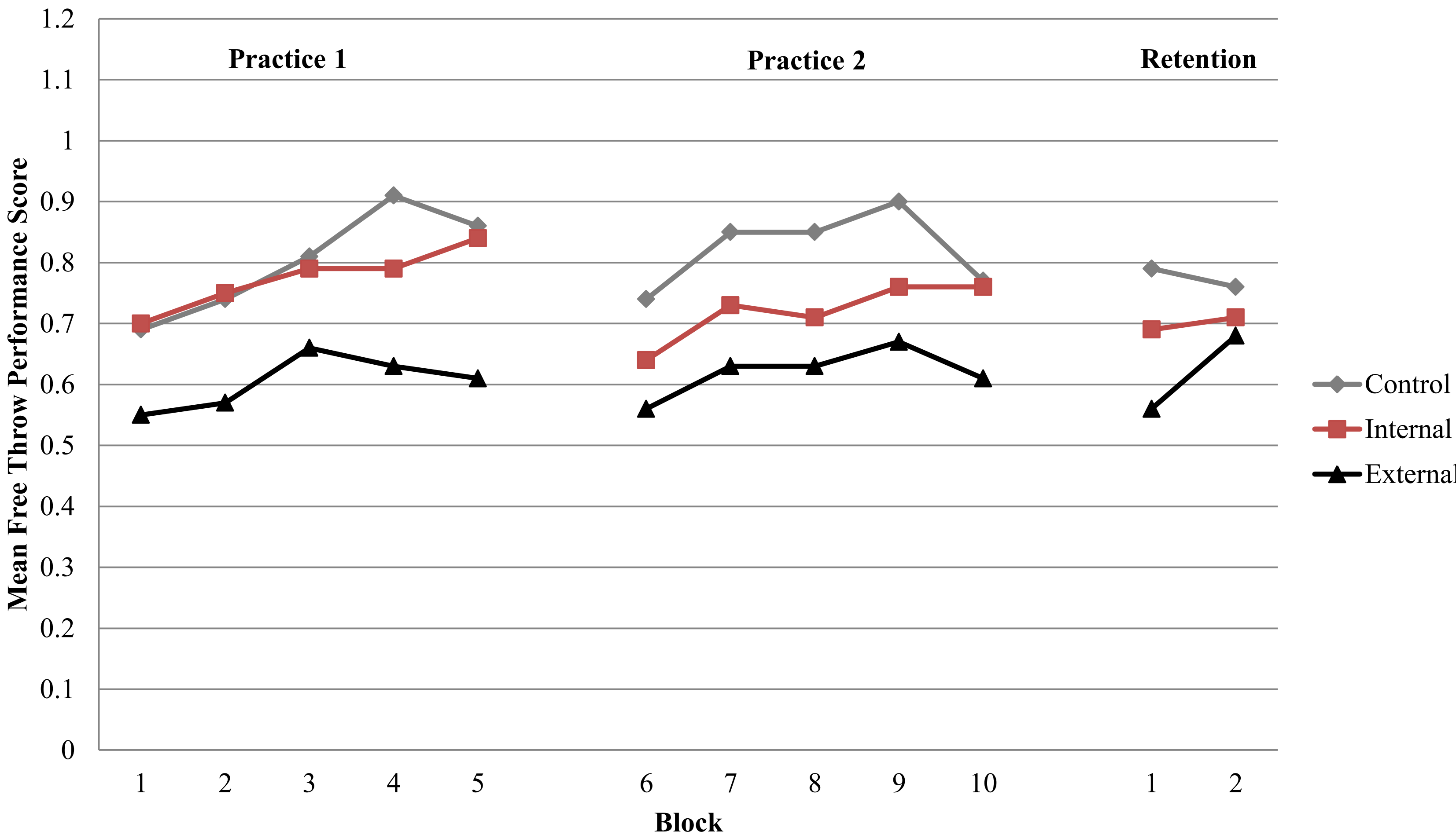

Figure 2.1 Mean free throw performance scores across blocks in practice and retention.

Table 2.1

Coding Scheme for Verbal Responses including Operational Definitions and Examples

Code	Sub-Code	Operational Definition	Example(s)
Informational Content (IN)		Information relevant to mediating task performance	
	Initial Instructions (IN-I)	Directed at one or more of the initial task instructions	"bend my knees"; "learned to put one hand under the ball and one on the side"
	Internal Focus Cues (IC-CI)	Directed at one or more internal attentional focus cues	"make L-shape"; "make my wrist go forward"
	External Focus Cues (IN-CE)	Directed at one or more external attentional focus cues	"balance the ball like a tray"; "create backspin on the ball"
	Goal (IN-G)	Directed at achieving a desired result	"to improve and get better"; "make one or two"
	Aiming (IN-A)	Directed at a target (e.g., basket, hoop, backboard)	"aiming at the basket"; "concentrate on goal and ball"
	Other (IN-O)	Directed at any other content relevant to task performance	"make sure I'm in right angle to goal"; "get the ball up in the air"
	Evaluative (IN-E)	Directed at self-assessment of strategies or performance relative to oneself or another	"thought I did better today"; "Tomas had more scores than me"
Irrelevant Content (IR)		Information not relevant to mediating task performance	"get to sleep early"; "my feet are sweaty"
Emotional Content (EM)		Feelings directed toward the task or a specific aspect of the task	
	Positive (EM-P)	Favorable feelings	"had fun, can't wait till Friday"; "basketball is fun"
	Negative (EM-N)	Unfavorable feelings	"this ball sucks"; scary because basketball is not my sport"
	Uncertain (EM-U)	Tentative feelings	"how good I will get at it"; "am I going to do a good job today"

Table 2.2

Percentages of Participants Reporting Informational Content by Subcategory across Practice Days (1 and 2) and Retention (R) for each Condition

Condition	I	CI	CE	A	G	O	E
Control							
1	7%	0%	0%	14%	29%	7%	14%
2	7%	0%	0%	29%	14%	7%	36%
R	14%	0%	0%	21%	29%	0%	21%
Internal							
1	0%	29%	0%	7%	57%	14%	7%
2	7%	21%	0%	0%	50%	7%	64%
R	7%	21%	0%	0%	43%	21%	43%
External							
1	0%	0%	0%	7%	21%	7%	43%
2	0%	0%	29%	0%	21%	7%	29%
R	7%	0%	21%	0%	29%	21%	29%

Note: Abbreviations for subcategory headings are as follows: initial instructions (I), internal focus cues (CI), external focus cues (CE), aiming (A), goal (G), other (O), and evaluative (E).

Table 2.3

Percentages of Participants Reporting Other Content by Subcategory across Practice Days (1 and 2) and Retention (R) for each Condition

Condition	IR	EM-P	EM-N	EM-U
Control				
1	21%	29%	14%	0%
2	21%	21%	7%	0%
R	29%	7%	14%	0%
Internal				
1	21%	7%	14%	7%
2	29%	7%	7%	7%
R	14%	14%	0%	7%
External				
1	7%	14%	14%	7%
2	7%	7%	14%	7%
R	29%	0%	7%	0%

Note: Abbreviations for subcategory headings are as follows: irrelevant (IR), emotional positive (EM-P), emotional negative (EM-N), and emotional uncertain (EM-U).

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CHAPTER 3: JOURNAL ARTICLE 2

THE EFFECT OF ATTENTIONAL FOCUS FEEDBACK ON MOTOR SKILL LEARNING IN CHILDREN[2]

[2] Perreault, M. E., & French, K. E. To be submitted to *Research Quarterly for Exercise and Sport*.

A common source of information available to learners about skill execution is feedback. Typically, feedback is provided after skill execution and based upon the learner's prior performance. There are two main forms of feedback: knowledge of results (KR) and knowledge of performance (KP). KR is information about the outcome of the movement. This might be inherent to the task in the way that a golfer can easily observe whether s/he missed a putt or augmented in the way that a golfer might learn from a spectator that he or she had holed a long chip onto a "hidden" green (Schmidt & Lee, 2005). KP, also termed kinematic feedback, is information about the quality of the movement. As with KR, this information can be available inherently, such as from the feel of the movement as it was executed, or be in an augmented form, such as feedback from a coach about an error in the movement pattern.

Feedback has been shown to have informational properties in that it helps learners reduce errors, correct them more quickly, and bring their movement patterns closer to the goal (Schmidt & Wrisberg, 2008). This is achieved by directing learner attention to the most relevant aspects of the task. The predominate form of augmented feedback provided to learners by teachers and coaches is KP. Given the emphasis on movement form and technique, this type of feedback tends to focus learners' attention on specific aspects of their movements. However, directing attention in this way is not necessarily the most advantageous for motor learning. In fact, Wulf (2007) has shown through a combination of anecdotal and experimental evidence that an external focus of attention, whereby one directs attention to the effects of the movement, is more beneficial than adopting an internal focus of attention, whereby one directs attention to the movements (see Table 1.1 for examples). To explain these findings, Wulf and colleagues (e.g., McNevin, Shea, &

Wulf, 2003; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001) proposed the constrained action hypothesis which postulates that an external focus allows unconscious, reflexive control processes to govern the action whereas an internal focus disrupts this automatic control by constraining the motor system.

Much of the research investigating attentional focus effects on motor learning has involved the use of verbal instructions or cues. For example, Wulf et al. (2001) had participants balance on a stabilometer after being instructed to adopt either an internal (keep feet horizontal) or external (keep markers horizontal) attentional focus. They found that participants who adopted an external focus had less postural sway in retention than those who adopted an internal focus. In addition to balance tasks, the advantage of an external focus has been replicated for learning golf pitches (Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007), basketball free throws (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Zachry, Wulf, Mercer, & Bezodis, 2005), and dart throws (Marchant, Clough, & Crawshaw, 2007; Marchant, Clough, Crawshaw, & Levy, 2009).

Given these robust findings, some researchers have attempted to determine the generalizability of external focus instructions to feedback. In an early study by Shea and Wulf (1999), four groups of participants practiced balancing on a stabilometer over two days. Two groups were instructed to focus on either keeping their feet the same height (internal) or keeping markers on the platform the same height (external) while two feedback groups received concurrent feedback via computer monitor that displayed a visual depiction of their horizontal deviation from neutral. Participants in the feedback/internal group were told the visual display represented their feet while participants in the feedback/external group were told it represented the markers. The authors found that both feedback groups had superior performance over the no feedback groups during practice and a retention test one day later. More notably, both external groups outperformed the internal groups during retention.

In an attempt to replicate these findings to learning realistic sport skills, Wulf, McConnel, Gartner, and Schwarz (2002) conducted two experiments using a volleyball serve and soccer pass. In the first experiment, novice and experienced volleyball players practiced a "tennis" serve during two sessions separated by a week. All participants were given one of four feedback statements following every fifth trial respective to their attentional focus condition, 2 (novice/experienced) X 2 (internal/external focus). The statements provided to the internal groups focused on mechanics while those provided to the external group were focused on movement effects relative to the ball. Participants were scored on accuracy and form (two raters) during practice and a retention test one week later. The authors found that the external groups were more accurate and had better form scores than the internal groups during practice and were more accurate than the internal groups during retention.

In their second experiment, Wulf et al. (2002) examined the interactive effects of feedback frequency and attentional focus on learning a lofted soccer pass. Participants with some soccer experience practiced the pass during a single session in which they received one of five feedback statements with either an internal or external focus every trial or every third trial, 2 (internal/external focus) X 2 (33%/100% feedback frequency). Participants were scored on accuracy during practice and a retention test one week later. The authors found that the external groups were more accurate than the internal groups and the 33% internal group was more accurate than the 100% internal group for both practice and retention. Interestingly, there were no differences between the two external groups for both practice and retention. This finding is disparate with previous research that supports the learning advantage of reduced feedback frequency. The authors argue that the beneficial effect of reduced feedback frequency may have more to do with the preponderance of internally focused feedback than the rate of delivery.

Even though preliminary findings support the generalizability of the external focus advantage via feedback (see Wulf, 2007 for a review), these studies have been almost entirely limited to adult populations. Consequently, little is known about the effects of attentional focus feedback in children. Although a few studies have included children (Emanuel, Jarus, & Bart, 2008; Perreault & French, 2013; Thorn, 2006), only one has investigated the effects of attentional focus feedback (Wulf, Chiviacowsky, Schiller, & Avila, 2010). Despite this gap in the literature base, generalizations of the external focus advantage are still often made from adults to children. This is particularly problematic given the information processing differences between adults and children that have the potential to differentially impact motor performance and learning.

A well-documented source of these differences is processing speed. Specifically, as children age, they are able to process information more quickly. One way in which processing speed has been shown to improve with age is the ability to process the same amount of information in a shorter period of time. This has been demonstrated with age related improvements in simple RT (Thomas, Gallagher, & Purvis, 1981) and processing of feedback (Gallagher & Thomas, 1980). Processing speed has been shown to increase with age in that more information can be processed in the same amount of time. For example, Thomas, Mitchell, and Solmon (1979) found that fourth graders were able to use precise feedback more effectively than second graders to improve their performance on a curvilinear positioning task.

Another major source of difference between adults and children lies in the functionality (i.e., control processes) of working memory. That is, as individuals age, they make better use of strategies and knowledge rather than simply acquiring a greater amount of memory storage. For example, Winther and Thomas (1981) found age related improvements in encoding strategies when participants were asked to remember locations on an apparatus resembling a clock face. Very young children used their "thinking cap" while older children used a pie graph and adults a clock face. Similarly, age related improvements in the use (Thomas, Thomas, Lee, Testerman, & Ashy, 1983) and quality (Gallagher & Thomas, 1984) of rehearsal strategies have also been reported as well as for strategies relevant to improved memory organization (Gallagher & Thomas, 1986).

Selective attention, the ability to attend to relevant stimuli in the environment, is a final information processing difference between adults and children that improves with age. According to Ross (1978), selective attention strategies progress in stages from over-exclusion to over-inclusion to selective attention. Prior to first grade (ages 5-6), children typically over-exclude in that they attend only to a single stimulus. As a result, the child is able to recall very little incidental information from the environment. From first grade to the beginning of adolescence (ages 5-12), over-inclusion tends to dominate; that is, children attend to most of the available environmental stimuli, both relevant and irrelevant, which results in higher recall of incidental information. During this phase, it is particularly important that children are provided with appropriate cues in order to direct their attention to the pertinent sensory information. The final stage, selective attention, is typically reached during early adolescence (ages 11-12) and is marked by the ability to attend to relevant stimuli while filtering out the irrelevant.

Given the information processing differences highlighted above, it is not surprising that there is some evidence to support the differential effects of motor learning variables on adults and children. For example, contradictory evidence for the motor learning advantages associated with reduced feedback (Goh, Kantak, & Sullivan, 2012; Sullivan, Kantak, & Burtner, 2008) and contextual interference (Hall & Boyle, 1993; Jarus & Goverover, 1999) have been found in children. There is also some evidence to suggest that children and adults are differentially affected by attentional focus instructions (Emanuel et al., 2008; Perreault & French, 2013). If a major goal of motor learning research is to inform practice in physical education and sport settings involving children and adolescents, it is premature to generalize from adult populations regardless of how robust the findings may be. Instead, it is vital that researchers attempt to replicate these findings in relevant populations for which they will be applied. Therefore, the purpose of this study is to determine the effect of attentional focus feedback on motor learning in children.

Method

Participants

Twenty-eight children between the ages of 9 and 11 years with no prior organized basketball experience (e.g., recreational leagues) were recruited from an afterschool program at an elementary school in the southeastern United States to volunteer for this study. Informed consent from legal guardians (see Appendix A) and assent from participants (see Appendix B) was obtained prior to the study in compliance with the university's Institutional Review Board.

Task, Apparatus, and Scoring

The task consisted of a basketball free throw using a 28.5" circumference basketball per AAU youth basketball equipment guidelines for this age range (Amateur Athletic Union, 2012). Participants shot from a 12 ft free throw line to a standard basketball goal set at a height of 9.5 ft in an indoor gymnasium. Free throw performance was scored based on a 3-point scale (Price, Gill, Etnier, & Kornatz, 2009). A score of 2 was given for a make, 1 for a near miss (ball hits rim), and 0 for a complete miss.

Procedure

Participants were randomly assigned to one of two gender stratified groups of equal size: (1) internal focus feedback or (2) external focus feedback. Testing was conducted individually over three days consisting of two identical practice sessions followed by a retention session approximately 24 hours later. Before beginning each practice session, all participants were provided with some initial instruction on how to perform a free throw. First, they viewed a video model of a correct free throw on a laptop computer followed by verbal instructions regarding correct free throw technique (adapted from Zachry et al., 2005). Next, participants viewed the video once more and received verbal cues as a reminder of the instructions. Finally, they were allowed five unscored warm-up trials to become familiar with the technique and equipment.

Following the warm-up trials for each practice day, participants performed 5 blocks of 10 practice trials with 1 minute breaks between blocks to prevent fatigue. During each block, participants received one of four feedback statements respective to their attentional focus condition following every third trial (see Table 3.1). Each statement was used at least once and selected on the basis of each participant's performance from the three preceding trials. It was stressed to each participant the importance of adopting this attentional focus during performance of the next trials. Approximately 24 hours following the second practice session, participants performed 2 blocks of 10 retention trials with a 1 minute break between blocks. No augmented feedback was given.

Manipulation Check

Following each day of practice and retention, participants were asked to respond to an open-ended question to serve as a manipulation check of the attentional focus manipulations as well as determine the types of "natural" thoughts experienced by the control group. Specifically, they were asked, "What were you thinking about today when you were practicing your free throw?" The format of the question was chosen to correspond with the recommendations of Ericsson and Simon (1993) for retrospective verbal reports in order to access traces of participants' working memory following task performance. Responses were recorded via audiotape verbatim; however, transcription of responses was summarized.

Data Analysis

Free throw performance. Alpha was set at .05 for all statistical analyses. Mean shooting score for each block in practice and retention was calculated. For the practice sessions, a 2 (Group) X 10 (Block) ANOVA with repeated measures on the last factor was conducted. For the retention session, a 2 (Group) X 2 (Block) ANOVA with repeated measures on the last factor was conducted.

Manipulation check. Responses to the manipulation check were analyzed using a verbal analysis method similar to Chi (1997). Each response was segmented into separate words and/or phrases representing distinct thought processes during performance.

Results

Free Throw Performance

All means and standard deviations are reported in Table C.2. The analysis revealed a significant group by block interaction for practice, $F(9,234) = 2.20$, $p < .05$). As illustrated in Figure 3.1, the external focus group generally outperformed the internal focus group until the eighth practice block wherein the internal focus group caught up in performance only to decline sharply during the last practice block. More noteworthy was the significant group by block interaction for retention, $F(1, 26) = 4.96$, $p < .05$, with the external focus group ($M = .94$, $SD = .39$) outperforming the internal focus group ($M = .56$, $SD = .41$) during the second block (see Figure 3.1). The group main effect in retention was also marginally significant, $F(1,26) = 2.89$, $p = .10$. These results provide evidence to suggest that external focus feedback is more beneficial than internal focus feedback for children learning a free throw.

Manipulation Check

After an examination of the verbal responses, two experimenters developed a coding scheme similar to Perreault and French (2013) based on the instructional content presented to participants and other content commonly observed in novice learners (cf. Nielsen & McPherson, 2001) to categorize each response segment. Three major categories emerged: informational, irrelevant, and emotional content. Informational content was defined as information relevant to mediating task performance. This category was further divided into seven subcategories: (1) initial instructions, (2) internal focus feedback, (3) external focus feedback, (4) aiming, (5) goal, (6) other, and (7) evaluative. Irrelevant content was defined as information not relevant to mediating task performance. Emotional content was defined as feelings directed toward the task or a specific aspect of the task. This category was further divided into three subcategories: (1) positive, (2) negative, and (3) uncertain. See Table 3.2 for operational definitions and examples of all subcategories. Response segments were then coded independently by the two experimenters and adequate inter-rater reliability was obtained (93% agreement). See Appendix E for an example of one experimenter's coding sheet.

Informational content. Percentages of participants reporting informational content by subcategory across conditions for practice and retention are presented in Table 3.3. Since the main purpose of the verbal responses was to serve as a manipulation check for treatment effectiveness, we first evaluated the use of feedback by each group. Participants in the internal focus group did not report use of any external focus feedback while approximately 7-14% reported using at least one internal focus feedback statement during practice and retention. Despite one participant in the external focus group reporting use of internal focus feedback in retention, approximately 29-50% of participants reported using at least one external focus feedback statement during practice and retention. This provides evidence to suggest that treatment manipulations were effective to some extent for each attentional focus group.

Although provided at the beginning of each practice day, initial instructions were rarely reported by either group (7-14%). Instead, additional types of information more commonly reported include aiming, goal, and evaluative content. With respect to aiming, greater percentages were reported by the external focus group (14-21%) than the internal focus group (0-7%). This trend was reversed for the evaluative content in which the internal focus group (36-57%) reported great percentages than the external focus group (7-21%). However, similar percentages were reported for the internal (14-36%) and external focus (21%) groups for goal content.

Finally, small percentages of each group (0-21%) reported using other information during practice and retention that did not fall into any of the former subcategories. Most of this content (e.g., keep the ball in front) is thought to have come from previous free throw instruction provided by a teacher, peer, or family member while other statements appear to reflect self-generated strategies used for individual purposes (e.g., get the ball higher, take a deep breath).

Irrelevant content. Since participants were novices, it is not surprising that many reported using content completely irrelevant to mediating task performance (see Table 3.4). Both groups reported similar percentages during both practice days; however, the external focus group (50%) reported more than double that of the internal focus group (21%) during retention. Responses indicated that a few participants weren't thinking of anything at all (e.g., mind was blank) while others reported thoughts concerning school (e.g., homework, social studies sheet) or other miscellaneous content (e.g., don't hurt my finger). Although not relevant to task performance, several of the responses were basketball related (e.g., how can I practice over the weekend) and may provide some indication of participants' motivation for performing the task throughout practice and retention.

Emotional content. Although infrequent, participants in each group indicated some type of emotional processing during practice and/or retention (see Table 3.4). Participants in the internal focus group only reported emotional content during the first day of practice with 7% positive, 21% negative, and 14% uncertain. This content was reported even less by the external focus group. Only one participant reported uncertain emotional content during the first practice day and only one reported positive emotional content during retention. The positive emotional content generally indicated some level of enjoyment with the task (e.g., glad my mom signed me up) while negative emotional content was mostly directed at perceived task difficulty (e.g., it was hard because I never did that before). Uncertain emotional content tended to reflect participants' insecurity with the task (e.g., when I throw it what way should I throw it) or their performance capabilities (e.g., am I going to make it or not).

Discussion

The purpose of this study was to expand the current literature base on the effectiveness of attentional focus feedback to children, an understudied population. Participants aged 9-11 practiced a modified free throw over two days while receiving feedback statements respective to their attentional focus condition and returned approximately 24 hours later to complete a retention test. Based on previous literature, it was hypothesized that the external focus group would outperform the internal focus group during retention. Along with being assessed on free throw performance, participants were also asked to respond to a retrospective verbal report following each day to serve as a manipulation check for treatment effectiveness. Responses were analyzed using a coding scheme similar to Perreault and French (2013) based on informational content presented directly to, or generated by participants and additional content typical of novice performers.

Results from free throw performance scores showed a significant interaction in retention with the external focus group outperforming the internal focus group during the second block of trials. This provides evidence to support the external focus advantage for motor learning in children when provided via feedback, thus corroborating predictions from adult populations. Findings are less consistent when compared to the single study we discovered examining attentional focus feedback effects with children (Wulf et al., 2010). First, Wulf et al. found an external focus advantage for 10-12 year olds learning a soccer throw-in only when feedback was given at a 100% (versus 33%) relative frequency while the current study found the same advantage when feedback was given at a relative rate of just 30%. In addition, the external advantage reported by Wulf et al. was only for form scores, not accuracy, which the authors' argued was due to the nature of feedback given. However, this explanation is not supported by the current study since an external focus advantage was found for accuracy even when the feedback emphasized technique. Thus, continued research is needed in order to gain greater insight attentional focus feedback effects with children both generally and in relation to other relevant variables.

When compared to studies using attentional focus instructions or cues, the results of the current study support those of Thorn (2006) who found an external focus advantage for children learning a balance task. However, they do not support those of Emanuel et al. (2008) and Perreault and French (2013) who found no external focus advantage for children learning a dart throw and basketball free throw, respectively. The conflicting evidence between the current study and Perreault and French is especially surprising given their similarities in participants, tasks, measures, and procedures. Moreover, two of the feedback statements for each condition from the current study are identical to the cues used in the former. One source of evidence to potentially explain the difference in findings comes from participant responses to the retrospective verbal reports. In Perreault and French's (2013) study, similar percentages of participants in the treatment groups (21-29%) reported using their respective attentional focus cues during practice and retention. This is in contrast to the current study in which the percentage of participants reporting the use of feedback was much greater in the external focus group (29-50%) than the internal focus group (14-21%). Therefore, it may be that higher usage of attentional focus feedback by the external focus group contributed to great gains in learning rather than just the focus itself.

Another potential explanation lies in the reported use of aiming content by participants. The control group in Perreault and French reported using similar percentages of aiming cues (14-29%) to that of the attentional focus cues of the treatment groups. Since aiming was almost solely reported by the control group, the authors argued that the they might have received similar benefits to the external focus group due to commonalities in the proposed mechanisms underlying the effects of quiet eye (location-suppression hypothesis: Vickers, 1996) and attentional focus (constrained action hypothesis). This may also help account for the external focus advantage found in the current study since a higher percentage of the external focus group (14-21%) reported using aiming content than the internal focus group (0-7%). Moreover, participants in the external focus group who reported using aiming content were often not the same as those who reported using feedback. Given that these two sources of information may work similarly for aiming tasks, the external focus group may have received potential benefits beyond those associated with attentional focus feedback alone.

A more general explanation for the difference in findings of the current study with those using attentional focus instructions or cues (Emanuel et al., 2008; Perreault & French, 2013) involves the nature of feedback itself. First, feedback is commonly provided at a greater rate than instructions or cues. For example, studies finding no external focus advantage for learning provided instructions/cues a mere five times during 50 practice trials (Emanuel et al.; Perreault & French) whereas the current study, which did find an advantage, provided feedback 15 times during the same number of trials. This increased availability of feedback may make it easier for children to keep relevant information available in working memory despite having less sophisticated control processes than adults (Gallagher & Thomas, 1984; Thomas et al., 1983; Winther & Thomas, 1981). Additionally, feedback has been shown to have reinforcing and motivational properties (Schmidt & Wrisberg, 2008) that provide benefits beyond informational content alone. Specifically, individuals able to access and use feedback tend to have consistent improvements in performance, try harder, persist longer, and report greater enjoyment.

As with all research, this study is not without limitations. First, data collection was conducted in a school setting. Although this type of location increases ecological validity, it does lessen the amount of experimental control. Fortunately, we were able to prevent or reduce several common issues by using an afterschool program. However, one problem we were unable to avoid occurred when other activities took place in the gym or multipurpose room during data collection. While most facilities were large enough to accommodate multiple activities, several participants indicated that they were distracted by, or uncomfortable with practicing in front of peers. Thus, it is possible that some participants' performance was negatively affected due to loss of focus or increased anxiety.

An additional limitation concerns size and strength variations within the study's sample commonly observed in this age range due to differences in maturational timing (Haywood & Getchell, 2009). In order to compensate for these variations, body scaling would have been ideal. However, it was not feasible to continually adjust the goal height and free throw distance based on the height of each participant. Thus, some participants may have been disadvantaged by the fixed task conditions. This is further illustrated in some of the performance scores that had an overall mean close, or equal to zero as well as some of the other informational content reported by participants (e.g., get the ball higher). Even though these occurred predominately in the internal focus group, they were rare and not likely to create an advantage or disadvantage for any one group.

In conclusion, this study adds to the limited literature examining the effect of attentional focus feedback on motor learning in children. As predicted from adult populations, we found a significant learning advantage for participants receiving external focus feedback. Possible explanations include the external focus group's greater reported use of feedback and aiming content as well as the added benefits of feedback over instructions in terms of quantity, motivation, and reinforcement. Future research should continue to expand this body of literature to other tasks, age groups, and related variables (e.g., feedback frequency) as well as incorporate retrospective verbal reports to examine participants' thought processes during task performance. Moreover, further investigation into explanations regarding aiming content (e.g., quiet eye) and feedback advantages may provide greater insight into the underlying mechanisms associated with the effects of attentional focus feedback on motor learning and performance.

Table 3.1

Attentional Focus Feedback Statements by Condition

Internal Focus Feedback	External Focus Feedback
• Make an L-shape with your arm and rest the ball on your finger pads	• Balance the ball on your hand like a waiter balances a tray
• Line up your hand and eye with basket	• Focus on a spot just above the rim
• Extend your knees and arms together as you shoot the ball	• Shoot the ball as if it is going over a volleyball net
• Snap your wrist forward when releasing the ball	• Try to make the ball spin backwards when you release it

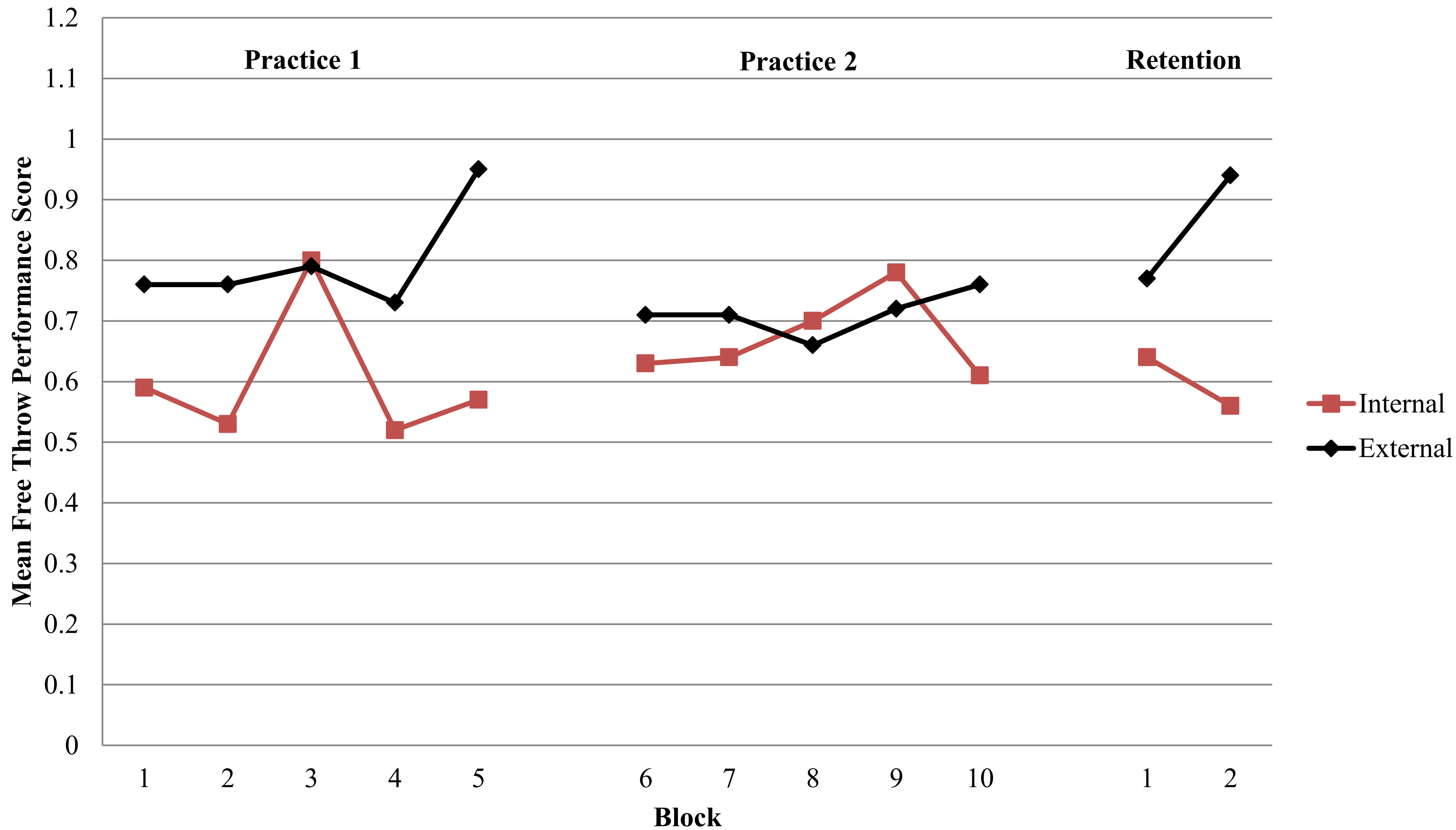

Figure 3.1 Mean free throw performance scores across blocks in practice and retention.

Table 3.2

Coding Scheme for Verbal Responses including Operational Definitions and Examples

Code	Sub-Code	Operational Definition	Example(s)
Informational Content (IN)		Information relevant to mediating task performance	
	Initial Instructions (IN-I)	Directed at one or more of the initial task instructions	"bending knees"; "stay behind the line"
	Internal Focus Feedback (IN-FI)	Directed at one or more internal attentional focus feedback statements	"making an L-shape with my arm"; "flicking my wrist"
	External Focus Feedback (IN-FE)	Directed at one or more external attentional focus feedback statements	"shoot it over a volleyball net"; "the spot up there on the backboard"
	Goal (IN-G)	Directed at achieving a desired result	"trying to make it in the hoop"; "shoot the ball in the basket"
	Aiming (IN-A)	Directed at a target (e.g., basket, hoop, backboard)	"aim for the red line at the top"; "aiming for the middle"
	Other (IN-O)	Directed at any other content relevant to task performance	"get the ball higher"; "keep my legs pointed to the goal"
	Evaluative (IN-E)	Directed at self-assessment of strategies or performance relative to oneself or another	"I did good"; "I wasn't lining up very good"
Irrelevant Content (IR)		Information not relevant to mediating task performance	"finishing my homework"; "what my dad is doing right now"
Emotional Content (EM)		Feelings directed toward the task or a specific aspect of the task	
	Positive (EM-P)	Favorable feelings	"glad my mom signed me up"; "so happy it's Friday but sad I don't get to do this anymore"
	Negative (EM-N)	Unfavorable feelings	"felt a little more pressure than usual"; "it was hard because I never did that before"
	Uncertain (EM-U)	Tentative feelings	"am I going to make it or not"; "if I did wrong would you take me out"

Table 3.3

Percentages of Participants Reporting Informational Content by Subcategory across Practice Days (1 and 2) and Retention (R) for each Condition

Condition	I	FI	FE	A	G	O	E
Internal							
1	14%	21%	0%	7%	36%	0%	36%
2	7%	14%	0%	7%	14%	7%	57%
R	7%	14%	0%	0%	21%	21%	50%
External							
1	7%	0%	50%	21%	21%	7%	14%
2	7%	0%	36%	21%	21%	0%	21%
R	7%	7%	29%	14%	21%	21%	7%

Note: Abbreviations for subcategory headings are as follows: initial instructions (I), internal focus feedback (FI), external focus feedback (FE), aiming (A), goal (G), other (O), and evaluative (E).

Table 3.4

Percentages of Participants Reporting Other Content by Subcategory across Practice Days (1 and 2) and Retention (R) for each Condition

Condition	IR	EM-P	EM-N	EM-U
Internal				
1	21%	7%	21%	14%
2	7%	0%	0%	0%
R	21%	0%	0%	0%
External				
1	29%	0%	0%	7%
2	21%	0%	0%	0%
R	50%	7%	0%	0%

Note: Abbreviations for subcategory headings are as follows: irrelevant (IR), emotional positive (EM-P), emotional negative (EM-N), and emotional uncertain (EM-U).

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CHAPTER 4: DISCUSSION

The purpose of this research project was to examine the effects of attentional focus cues and feedback on motor skill learning in children. Two separate studies were conducted. The first study (see Chapter 2) was designed to examine the effect of attentional focus cues on learning. Participants ages 9-11 performed a modified free throw using either an internal, external, or no attentional focus. Based on previous literature, it was hypothesized that the external group would outperform the internal focus and control groups on a retention test. Despite finding no significant differences between groups, responses to the retrospective verbal report suggests that the treatment manipulations were somewhat effective and participants were sufficiently motivated and/or engaged in the task. However, aiming cues used by the control group and goal directed content used across groups could have potentially negated some of the treatment effects.

The second study (see Chapter 3) was designed to examine the effect of attentional focus feedback on learning. Participants ages 9-11 performed a modified free throw while receiving either internal or external focus feedback statements. Based on previous literature, it was hypothesized that the external group would outperform the internal focus group on a retention test. As predicted, we found a significant learning advantage for participants receiving external focus feedback. Possible explanations include the external focus group's greater reported use of feedback and aiming content as well as the added benefits of feedback over instructions in terms of quantity, motivation, and reinforcement.

Future research should continue to expand this body of literature to other tasks, age groups, and related variables (e.g., feedback frequency) while also incorporating retrospective verbal reports to examine participants' thought processes during task performance. Moreover, explanations regarding potential commonalities between mechanisms underlying aiming content (e.g., quiet eye) and attentional focus should be explored as well as how feedback may benefit children more than instructions or cues to compensate for less sophisticated use of working memory processes during learning.

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APPENDIX A: INFORMED CONSENT FORM

CONSENT FORM: "The Effects of Attentional Focus Cues and Feedback on Motor Skill Learning in Children"

Melanie Perreault, M.S., Principal Investigator
Department of Physical Education and Athletic Training

Your child is invited to participate in a study to determine the effect of different types of instructional cues and feedback on learning a basketball free throw. My name is Melanie Perreault, a doctoral student at The University of South Carolina, Department of Physical Education and Athletic Training. I am asking for permission to include your child in this study because the results of the research may potentially help physical education teachers and youth sport coaches provide more effective instruction and feedback to their students and athletes when learning sport skills. I expect to have 75 participants in the study.

If you allow your child to participate, s/he will practice shooting a basketball from the free throw line over three consecutive days during her/his afterschool program. Your child will shoot free throws in 5 sets of 10 the first day, 5 sets of 10 the second day, and 2 sets of 10 the third day. Rest time between each set will be provided. Before practicing the free throw, your child will receive verbal instructions and a video model on how to perform the free throw correctly. Then depending on which group your child is assigned to, s/he may receive additional free throw related instruction or feedback. After the first and second practice day, your child will also be asked to answer some verbal questions about what s/he was thinking about while practicing the free throws.

Information will be collected on your child's demographics (e.g., age, gender), free throw accuracy, and responses to the verbal questions. This information will remain confidential and will be disclosed only with your permission. Additionally, your, or your child's, name will not appear on any of the information collected and will be kept in the principal investigator's locked file cabinet and password protected computer.

There is minimal risk associated with your child's participation in this study. S/he might experience embarrassment typically associated with learning a new sport skill in everyday life. Thus, s/he is able to stop participation at any time. There are potential benefits for your child to participate in this research project. S/he may learn a new sport skill, become interested in the sport of basketball, and/or discover more about how to learn and about her/his potential for learning skills of this type.

This research study is not connected with your child's afterschool program and will not affect her/his present of future relationship with the school. If you have any questions about the study, please ask me. If you have any questions later, contact me at (904) 838-

9025 or m.perreault@live.com. If you have any questions or concerns about your child's participation in this study, contact Thomas Coggins, Director, Office of Research Compliance, at (803) 777-7095 or tcoggins@mailbox.sc.edu.

You may keep a copy of this consent form.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow her/him to participate in the study. If you later decide that, you wish to withdraw your permission for your child to participate in the study, simply tell me. You may discontinue her/his participation at any time.

______________________________	________________
Printed Name of Child	Child's DOB
______________________________	________________
Signature of Parent or Legal Guardian	Date
______________________________	________________
Signature of Investigator	Date

For IRB Staff Use Only
University of South Carolina
IRB Number: Pro00016648
Date Approved 4/12/2012
Version Valid Until: 4/11/2013

Appendix B: Assent Form

ASSENT FORM: "The Effects of Attentional Focus Cues and Feedback on Motor Skill Learning in Children"

Melanie Perreault, M.S., Principal Investigator
Department of Physical Education and Athletic Training

I am a researcher from the University of South Carolina. I am working on a study about learning a basketball free throw and I would like your help. I am interested in learning more about how different types of instructions and feedback help children learn sport skills. Your parent/guardian has already said it is okay for you to be in the study, but it is up to you.

If you want to be in the study, you will be asked to do the following:

- Practice shooting basketball free throws several times over three days at your school/after school program.
- Use some instructions and/or feedback while you practice the free throw.
- Answer some verbal questions about what you were thinking about while practicing the free throws.

Any information you share will be private. No one except me will know how well you performed the free throws or the answers to the questions.

By choosing to be in this study, you might learn a new sport skill, become interested in basketball, and/or have more confidence in your ability to learn sport skills. There is a possibility that you might become embarrassed when you are practicing the free throws. This is normal. However, if it bothers you too much, you can choose to stop practicing at any time.

You don't have to help with this study. Being in the study isn't related to your regular class work and won't help or hurt your grades. You can also drop out of the study at any time, for any reason, and you won't be in any trouble and no one will be mad at you.

Please ask any questions you would like to.

Signing your name below means that you have read the information about the study (or it has been read to you), that any questions you may have had have been answered, and you have decided to be in the study. You can still stop being in the study any time you want to.

Printed Name

Signature

Date

For IRB Staff Use Only
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Version Valid Until: 4/11/2013

Appendix C:

Means and SDs for Free Throw Performance

Table C.1

Study 1 Means and SDs for Free Throw Performance across Blocks

Condition	Practice 1					Practice 2					Retention	
	1	2	3	4	5	6	7	8	9	10	1	2
Control	.69 (.43)	.74 (.41)	.81 (.38)	.91 (.39)	.86 (.38)	.74 (.33)	.85 (.35)	.85 (.39)	.90 (.39)	.77 (.41)	.79 (.39)	.76 (.46)
Internal	.70 (.53)	.75 (.45)	.79 (.50)	.79 (.45)	.84 (.52)	.64 (.46)	.73 (.44)	.71 (.51)	.76 (.44)	.76 (.46)	.69 (.53)	.71 (.50)
External	.55 (.48)	.57 (.55)	.66 (.56)	.63 (.58)	.61 (.57)	.56 (.57)	.63 (.53)	.63 (.63)	.67 (.62)	.61 (.56)	.56 (.55)	.68 (.64)

Table C.2

Study 2 Means and SDs for Free Throw Performance across Blocks

Condition	Practice 1					Practice 2					Retention	
	1	2	3	4	5	6	7	8	9	10	1	2
Internal	.59 (.44)	.53 (.43)	.80 (.45)	.52 (.31)	.57 (.37)	.63 (.44)	.64 (.46)	.70 (.49)	.78 (.43)	.61 (.49)	.64 (.46)	.56 (.41)
External	.76 (.44)	.76 (.26)	.79 (.41)	.73 (.36)	.95 (.38)	.71 (.33)	.71 (.33)	.66 (.37)	.72 (.40)	.76 (.28)	.77 (.41)	.94 (.39)

Appendix D:

Experimenter Coding Sheet for Study 1

Code/Subcode	Control	Internal	External
IN-I	knees bent, wrist spring (104-2)	bend my knees (121-3)	focus on flicking (204-3)
	where hand is going and bend knees (104-3)	learned to put one hand under ball and one on the side (117-2)	
	snapping wrist and not stepping over line (207-1)		
	where my feet were and not pass the line (207-3)		
Code/Subcode	**Control**	**Internal**	**External**
IN-CI		put fingers in the right place (121-1,3)	
		make L-shape (121-2; 117-1,2,3; 115-1; 219-1)	
		bend my wrist (121-2)	
		make goose head (117-2,3)	
		noticed after 10th shot I wasn't using my fingerpads (115-2)	
		make my wrist go forward (217-3)	
Code/Subcode	**Control**	**Internal**	**External**
IN-CE			balance the ball like a tray (102-2; 204-3)
			I should hold it like a waiter holds a tray and create backspin (215-3)
			spin forward or backward (213-2)
			create backspin on the ball (209-2,3)
			how to balance like a waiter carrying a

			tray and get backspin (204-2)
Code/Subcode	**Control**	**Internal**	**External**
IN-A	concentrating on where ball is (105-2)	look at the basket (219-1)	try to aim for the middle of the board (204-1)
	aiming at the target (109-1)		
	aiming at the basket (109-2,3)		
	making sure ball in lined up with goal (104-2)		
	concentrate on goal and ball (104-3)		
	aim for middle (223-1)		
	aim correctly (223-2,3)		
Code/Subcode	**Control**	**Internal**	**External**
IN-G	make sure the ball goes in the goal (104-3)	wanted to do good and score, make shots (117-1)	try as hard as I can (123-2)
	make one or two (203-1)	wanted to get better score (117-2)	do your best, try hard, and have fun (114-3)
	make sure to hit backboard and inside of hoop (223-1)	try to do my best (117-3; 106-3)	just trying to make shots (102-3)
	that ball goes through net (223-3)	going to be easy, could get every shot (112-1)	I had to make it every time (215-3)
	to get better (212-1)	gonna be better (112-2,3)	trying to make the goal (220-1; 209-3)
	to improve better than I did yesterday (212-2)	knew I was going to make lots of baskets (112-3)	making it (220-2)
	to improve and get better (212-3)	going to make it (106-1; 202-1)	how many shots I was going to make (213-1)
	trying to make the shot (205-1)	if I didn't get baskets I would still do a good job and can still get two baskets (112-2)	make the ball go in the basket (209-1,2)
	try to focus on making the goal and trying not to miss (205-2,3)	make a good shot (106-2)	
		focus on goal of 10 because I think I've made 5 before (115-1)	
		wanted to beat number from yesterday (115-2)	
		wanted to make 10 out of 20 (115-3)	

		I'll keep trying to get close (103-2)	
		gonna get good and make it at least once (103-3)	
		wanted success (208-1)	
		wanted to make a goal (210-1)	
		make it or not (211-1)	
		hope I make it (211-2)	
		going to do a better job today (218-3)	
		reaching my goals (202-2)	
		even if it looked hard could get as many as I could (112-1)	

Code/Subcode	Control	Internal	External
IN-O	staying balanced (104-2)	make it go higher (217-1,2,3)	jump forward (111-3)
	make sure I'm in right angle to goal (104-1)	make it go in a straight line (217-2)	form (220-3)
		get ball up in the air (121-1)	do it more one-handed to get me closer (214-2)
		a lot of pushing the ball up in the air and into basket, got to remember to push it up (106-3)	I should run up and throw it without stopping, it will make me throw it better (214-3)
		thinking about the distance (202-3)	wanted to keep the ball to the side (204-1)

Code/Subcode	Control	Internal	External
IN-E	thought I did better today (113-2)	might miss a bit (112-3)	I was worse, how can I not make this (123-1)
	after watching video and practicing yesterday it was a bit easier to aim at the target (110-2)	[wanted to beat my number from yesterday] but didn't (115-2)	need to do better (123-3)
	after practicing for two days and seeing video it seemed easier each time (110-3)	[wanted to make 10 out of 20] but didn't (115-3)	can throw high but not far, I don't do it that far away (111-1)
	practice more, get better (108-1,2)	[noticed after 10th shot I wasn't using my fingerpads that I was using my hands] that's why I was missing (115-2)	I've gotten closer (111-2)

	Tomas had more score than me (101-2)	I was getting close (103-2,3)	I got closer and made some, [jump forward] helped (111-3)
	never shot the ball like that and usually shot it like this - two handed (206-1)	getting better and better and closer (118-2)	tried my best (114-1,2)
	since it was the third time I might be better at it (206-3)	easy because I've been practicing for two days (118-3)	might make one but was rushing myself (114-2)
	to not be distracted by things (104-3)	tried my best (208-2,3)	harder than I thought (116-1)
	doesn't matter if I make a shot (203-2)	I did awesome (219-2)	easier than yesterday, more points (116-2)
		I made more than ever in my life (219-3)	kinda hard because last time it was shorter (116-3)
		so close (211-2)	I need to practice (214-1; 216-1,2,3)
		improve more, more shots than yesterday (218-2)	
		[focus on L shape] because I realized it helped me more (115-1)	
		[going to do a better job today] and I did (218-3)	
		trying to focus (202-2)	

Code/Subcode	Control	Internal	External
IR	about school tomorrow and homework for tonight (105-1)	am I going to learn anything else (106-1)	can't wait to get home to Cooper (107-3)
	get to sleep early (105-2)	am I going to take a long time (106-2)	nothing (119-3; 215-1,2)
	nothing (105-3; 203-3; 201-2)	nothing (211-3; 218-1)	what is going to happen when I'm done with my free throws (213-3)
	can't think of anything (108-3)	grow up to be an NBA player and support my team (208-1)	the more you do it the more you want to do it (116-3)
	my feet are sweaty (101-1)	hope to grow up to be a basketball player someday (208-2,3)	
	Mr. Nellums - PE teacher (206-2)	if I don't make one my brother will yell at me (210-2)	
	I'm gonna be a great basketball player when I group up (201-1)	one day might become pro player (202-2)	

	want to play a basketball game with my brother and friends (201-3)		
Code/Subcode	**Control**	**Internal**	**External**
EM-P	have fun (203-1,2; 205-1,3)	the sport is fun (208-3)	funner than I thought, can't wait to do it tomorrow (107-1)
	it wasn't so scary (113-2)	it was fun (103-1,2,3)	had fun, can't wait til Friday (107-2)
	it was fun but looked hard (110-1)		fun (116-1)
	fun (101-1)		
	baskeball is fun (101-2)		
Code/Subcode	**Control**	**Internal**	**External**
EM-N	scary because basketball is not my sport (113-1)	nervous (210-1)	sad only got one (107-2)
	scary again, I don't like basketball (113-3)	mad it was bouncing off rim (211-2)	upset it's over (107-3)
	the ball hates me (101-2)	harder than it looks (118-1)	probably going to do horrible (114-1)
	this ball sucks (101-3)		scary and weird (119-1)
	worried I might do bad (206-1)		nervous, scary, crazy (119-2)
Code/Subcode	**Control**	**Internal**	**External**
EM-U		how good I will get at it (103-1)	am I going to make all the shots or kind of make them (102-1)
		if I would do good or not (210-3)	what will I do wrong and what will I do right (213-2)
		am I going to do a good job today (106-2)	

Appendix E:

Experimenter Coding Sheet for Study 2

Code/Subcode	Internal	External
IN-I	I was trying to keep knees bent (130-1)	legs far apart and bent (127-2)
	my stance (129-1)	bend legs and stay behind the line (232-3)
	bending knees (130-2,3)	why is this way [one-handed] better than this way [two-handed] (235-1)
Code/Subcode	**Internal**	**External**
IN-FI	[I was trying to keep] arm in L-shape and flicking my wrist (130-1)	snapping my fingers (120-3)
	holding hand in right place (129-1)	
	trying to snap my arm better and work on my arms and legs to get it into the goal (134-2)	
	bending elbows and flicking my wrist (130-2)	
	practice snapping my hand (134-3)	
	making an L-shape with my arm (130-3)	
	not used to flicking my wrist (234-1)	
Code/Subcode	**Internal**	**External**
IN-FE		the volleyball net (120-1)
		trying to make this [the ball] go backwards and how to, where should I focus on (124-1)
		thinking about spot on the goal (122-1)
		I had questions like how to make the backspin (125-1)
		eyes on box above basket and hands holding ball like a waiter (127-1)
		I kept looking at the square (233-1)

		I need to focus more on spot above rim (133-2)
		remembering what [experimenter] was saying about focusing on a spot above the rim and shooting over a volleyball net (133-3)
		that big spot where I was trying to hit the basketball (120-2)
		a spot to focus on (124-3)
		keep my eyes on the square box above the basket, hold the ball like a waiter (127-2)
		hold ball like a waiter, shoot over volleyball net, focus on spot above net (127-3)
		shooting it at the square (232-1)
		shoot it over a volleyball net, get backspin on it more (232-2)
		the spot up there on the backboard (224-2)
		hitting the square above the rim (224-3)
Code/Subcode	**Internal**	**External**
IN-A	then I aim (129-1)	aim for the red line at the top (133-1)
	I was thinking about how I was going to line it up (131-2)	keep eyes focused on basket (127-3)
		shoot it in air where you want it to go (232-2)
		focusing on the rim and goal (225-2)
		if I hit the backboard in the square it will fall into the basket (224-1)
		shooting for the middle (222-1)
		I was thinking about hitting the middle and the net (222-2)
		focusing on the net, imagining ball hitting the net, imagining hitting the middle, hoping to hit square and land in middle (222-3)
Code/Subcode	**Internal**	**External**
IN-G	trying to go into the hoop (134-1)	make it (133-1)
	making the shots (135-1)	how can I make it as much as I can (124-2)
	thought I could make it (131-1)	trying to do my best (124-3)
	concentrate on the goal (231-1)	I hope I make it (122-2)
	focus on the goal (221-1)	shoot the ball in the basket (127-3)

	trying to make it in the hoop (135-2)	try to get it in hoop (230-1,2,3)
	if I was going to make it into the hoop (135-3)	the ball, imagined shooting into the basket (222-1)
	trying to get into the hoop (134-3)	
	trying to make it in the basket (130-3)	
	wanted to keep it straight (229-2)	
Code/Subcode	**Internal**	**External**
IN-O	keeping arms and legs straight (134-3)	keep my legs pointed to the goal (127-1)
	take a deep breath before I shoot (129-2,3)	keep the ball in front (127-3)
	get the ball higher (131-3)	hand motion (233-3)
		bend elbow (232-3)
Code/Subcode	**Internal**	**External**
IN-E	I did very bad (126-1)	not good at first but got better (125-1)
	pretty good, it was because I like exercising and playing on my scoots or bike (128-1)	if I practiced more I could master the free throw (233-1)
	I need to do better (231-1)	I did better than Monday (133-2)
	that I wasn't aiming right (226-1)	that I got better at it (125-2)
	I was off track (228-1)	why was I throwing the ball crooked (125-3)
	I did pretty good but at the same time bad, missed about 100 (126-2)	[the spot up there on the backboard] but I couldn't hit it (224-2)
	I did good (126-3; 228-3)	
	great (128-2)	
	I did a little better than yesterday (231-2; 228-2)	
	I wasn't doing very good (231-3)	
	I just keep missing (226-2)	
	I wasn't lining up very good (226-3)	
	more focused today, more focused on if I was going to make it (221-2)	
	not as focused because it was my last day (221-3)	
	how can I make it better, my hands pushed it one way (229-2)	
	ignoring the kindergartners, stay focused (229-3)	
	I did worse than yesterday (234-2)	
	I gonna do worse because first day I did kinda good, second day not as good (234-3)	

Code/Subcode	Internal	External
IR	how I am graded (221-1)	nothing (132-1,3; 225-1,3)
	mind was blank (229-1)	homework (132-2)
	the time when I started playing basketball with my family (128-3)	make a varsity team (233-1)
	finishing my homework (221-3)	don't hurt my finger (133-3)
	nothing (227-1)	everyone leaving (120-3)
	if I was doing a certain shot how would it affect playing 1 on 1 in PE (227-2)	I imagined I was in Madison Square Garden shooting free throws in front of fans (233-2)
	how can I practice over the weekend, what my dad is doing right now (227-3)	imagine I have teammates over here and crowd in stand (233-3)
		social studies sheet (235-1)
		school (235-2)
		spring break (235-3)
		Saturday - not having school (224-3)
Code/Subcode	**Internal**	**External**
EM-P	glad my mom signed me up (234-1)	so happy it's Friday but sad I don't get to do this anymore (122-3)
Code/Subcode	**Internal**	**External**
EM-N	nervous (135-1)	
	it was hard because I never did that before (226-1)	
	felt a little more pressure than usual (228-1)	
Code/Subcode	**Internal**	**External**
EM-U	when I throw it what way should I throw it (131-1)	if I did wrong would you take me out (120-1)
	am I going to make it or not (221-1)	