8-2020

Exploring the effects of traditional and expert-derived attentional focus cue structures on complex skill learning

Kaylee Woodard
University of Tennessee, Knoxville, kcouvill@vols.utk.edu

To the Graduate Council:

I am submitting herewith a dissertation written by Kaylee Woodard entitled "Exploring the effects of traditional and expert-derived attentional focus cue structures on complex skill learning." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Kinesiology.

Jeffrey T. Fairbrother, Major Professor

We have read this dissertation and recommend its acceptance:

Joshua T. Weinhandl, Rebecca A. Zakrajsek, Gary J. Skolits

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Exploring the effects of traditional and expert-derived attentional focus cue structures on complex skill learning

A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Kaylee Faith Woodard
August 2020

ACKNOWLEDGEMENTS

I would like to start by thanking my advisor, Dr. Jeffrey Fairbrother for his incredible leadership and mentorship during my doctoral program. Dr. Fairbrother, you have shown me how to lead well and mentor future students with genuine care. I'm truly indebted to you. I'd also like to thank the members of my committee, Dr. Joshua Weinhandl, Dr. Rebecca Zakrajsek, and Dr. Gary Skolits. I've learned invaluable things from each of you individually, and I am so grateful for your support as I took on this project that was meaningful to me. Next, the members of the motor behavior lab. I thoroughly enjoyed all the time spent in the MBL with Andy Bass, learning from each other, laughing at silly things, and forming a wonderful friendship. Although too brief, I'm also thankful for the great times I've shared with Logan Markwell and Dr. Jared Porter. Logan, thank you specifically for your help with this project and for your amazing friendship. Dr. Porter, thank you for your constant encouragement and your diligence to teach me so many meaningful things in our field, even in the short time I've known you.

To my mom, dad, and "baby" brother - I am where I am today largely because of you. There are no words to describe the love and support you have shown me throughout my entire life. I can only hope to repay you one day. Families don't get any better than you!

To my "new" family – my sister-in-love and the Woodards – I am so thankful that you are in my life. Thank you for your love, your support, and the joy you all bring to me.

To my husband, Nick Woodard – There are no words. Thank you for being my constant rock through my journey as a doctoral student. Thank you for all the meals cooked, laundry folded, and uplifting words of support you've given me as I finished this project. I love you, and I thank God for you every day!

To my jump rope family – You were the inspiration behind this project. Thank you for helping to shape me into the person I am today.

"Now all glory to God, who is able, through his mighty power at work within us, to accomplish infinitely more than we might ask or think. Glory to him in the church and in Christ Jesus through all generations forever and ever! Amen."

Ephesians 3:20

ABSTRACT

Instructions that direct attention externally have been shown to enhance motor performance. However, research on learning effects has produced mixed findings, particularly in skilled populations, and particularly when realistic instructional protocols have been used. Most studies have presented an overly simplistic view of attention, such that all-internal focus protocols are contrasted with all-external focus protocols. Expert performers, however, have reported adopting combined approaches, revealing the need for research to test more realistic instructions. The current project was a two-part study designed to investigate the effects of realistic focus instructions on performance and learning. Study 1 was an exploratory study of expert jump rope athletes' attentional strategies during the learning process. Results showed that experts focused on a wide range of cues related to control of the upper limbs and the rope as well as the movements of the lower body. Most cues were internal or non-distinguishable (i.e., neither clearly internal nor clearly external) and were often used in the context of stated externally-focused goals. Study 2 provided an experimental test of focus instructions modeled after experts' foci. Four groups of near-expert jump rope athletes practiced new skills under various instructions. The internal focus (IF) and external focus (EF) groups were given traditional internal and external focus instructions, respectively. The expert modeled (EM) group was given instructions that were based on experts' reported focus strategies. The expert modeled-autonomous (EM-A) group was given the expert modeled instructional set but was allowed to choose how they used the instructions. All groups completed a baseline assessment, four practice sessions, and a learning assessment. Results of a chi-square test of independence revealed no relationship between group assignment and performance during baseline or practice. There was a significant relationship between group assignment and performance during the learning assessment (*p* < .05). Specifically, the IF group performed worse than expected while the EM group performed better than expected. Findings support previous research showing internal focus learning detriments compared to external focus conditions and also provide new insight into the advantages of using instructional approaches modeled after experts' strategies. Implications and suggestions for future research are discussed.

TABLE OF CONTENTS

CHAPTER 1

Introduction

Effective performance of a wide variety of motor skills is essential for success in athletic endeavors, occupational pursuits, and even many activities of daily living. As such, a substantial amount of empirical research has been dedicated to exploring strategies for enhancing motor performance and skill acquisition. A growing subset of this research has specifically examined the effects of instructions and feedback which are designed to direct attentional focus.

Attentional focus, conceptualized as the deliberate and effortful allocation of attentional resources (Magill, 2011), has been a topic of interest to scholars for many decades (e.g., Bernstein, 1996; James, 1890). Only recently, however, have empirical tests of attentional focus instructions and their impact on motor performance and learning emerged in scientific literature. Within this line of research, attentional focus has been operationalized dichotomously as being directed either internally or externally. An internal focus of attention involves concentrating on controlling body movements, whereas an external focus of attention involves concentrating on the *effects* of movements on the environment (Wulf et al., 1998). Using an example of balancing on an unstable platform, an internal focus might involve attending to the movement of the feet. An external focus might involve attending to the movements of the platform. The effects of internal and external focus instructions on motor performance and learning have been tested repeatedly over the past two decades, producing a body of evidence that generally supports external foci as advantageous compared to corresponding internal foci (for a review see Wulf, 2013). When interpreting the results of this literature it is important to distinguish between effects on performance and learning. Motor *performance* refers to the immediately observable quality of skill execution. In research contexts, motor performance is measured while the experimental manipulation (e.g., an attentional focus instruction) is present. Motor *learning*, however, is inferred from changes in performance quality that are demonstrated after the removal of experimental manipulations, usually during retention or transfer tests. Thus, learning implies a relatively stable and persistent improvement in an individual's capability to execute a motor skill (Magill, 2011).

Research examining motor performance has shown that focusing externally tends to yield advantages over focusing internally. Such findings align with the tenets of the ideo-motor theory (Harleb, 1861; James, 1890; Lotze, 1852, as cited in Koch, Keller, & Prinz, 2004) and the action effect hypothesis (Prinz, 1997). According to these perspectives, actions are represented in the mind of a performer based on their intended effects, and therefore, directing attention to these intended effects should trigger smooth execution of appropriate movement patterns. The specific advantages of external focus instructions compared to internal focus instructions have been explained most recently by the Constrained Action Hypothesis

(Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). This hypothesis proposes that focusing on the effects of movements (i.e., externally) serves to promote the use of automatic control processes, thus enhancing movement effectiveness and efficiency. Focusing internally on the control of movement, however, is posited to hinder performance by disrupting automated control processes. Support for the Constrained Action Hypothesis has accumulated through studies demonstrating increased frequency of movement adjustments (e.g., McNevin, Shea, & Wulf, 2003), enhanced muscular coordination (e.g., Vance et al., 2004), and increased availability of attentional resources (e.g., Poolton et al., 2006, experiment 1; Wulf, McNevin, & Shea, 2001) under external focus conditions.

The effects of external focus instructions on immediate performance have been confirmed across a variety of skills, including object projection tasks such as dart throwing (e.g., Hitchcock & Sherwood, 2018) and free-throw shooting (e.g., Zachry et al., 2005), force production tasks such as jumping (e.g., Becker et al., 2018; Wu et al., 2012), and a variety of continuous tasks such as swimming (Stoate & Wulf, 2011). The effects of external focus instructions have also extended across different populations. Specifically, children and adolescents (Abdollahipour et al., 2017; Coker, 2019) as well as adult populations (e.g., Becker & Smith, 2015) have been shown to perform more effectively when instructed to focus on external targets (compared to internal targets). Some conflicting results, however, have emerged in older adults and in expert performers. Older adults tend to perform equivalently on balancing tasks under both internal and external focus conditions (Baniasadi et al., 2018; Chow et al., 2019). Experts have also responded differently to focus instructions, sometimes excelling under control (no instruction) conditions (e.g., Couvillion & Fairbrother, 2018; Wulf, 2008). Such findings indicate that perhaps experts have developed individually optimized focus strategies. Despite these contradictory findings, there remains a relatively large amount of support for external focus as a means to enhance motor performance.

Another subset of research has explored the effects of attentional focus instructions and feedback on motor *learning*. Although these effects have been studied for two decades, theoretical explanations for the learning effects of external focus instructions were absent from the literature until the publication of OPTIMAL (Optimizing Performance Through Intrinsic Motivation and Attention for Learning) Theory (Wulf & Lewthwaite, 2016). OPTIMAL Theory presents a combined attentional and motivational approach to explain the conditions which have been shown to facilitate motor learning. Specifically, the theory posits that learning is facilitated through an external focus of attention, autonomy support, and enhanced expectancies. Autonomy support involves the provision of choices which give the learner either actual or perceived control over aspects of their practice environments. Enhanced expectancies involve the learner's beliefs or expectations regarding the potential for achieving positive performance outcomes in the future. These factors are thought to work both independently and interdependently to increase the learner's focus on the task goal and decrease focus on self through augmented goal-action coupling. This process is posited to lead to enhanced performance which, in turn, facilitates learning. The prediction that learning is enhanced *through* positive performance outcomes directly contradicts previous conclusions about motor learning that have emerged from earlier literature. Specifically, a substantial amount of research has shown that learning is enhanced through manipulations which are associated with stagnant or even depressed performance in acquisition (for a review see Magill & Hall, 1990). OPTIMAL theory does not account for these findings.

With regard to attentional focus literature, OPTIMAL theory's predictions draw upon the results of existing research showing enhanced performance and learning in externally instructed groups compared to internally instructed groups. For example, Lohse (2012) tested participants in an isometric force production task and found that participants who were asked to focus on the platform (externally) performed more accurately than those who were asked to focus on the contraction of their calf muscle (internally) during both acquisition and retention testing. Similar findings have been generated in other tasks such as riding a pedalo (Abdollahipour et al., 2019, experiment 2; Totsika & Wulf, 2003), balancing on a stability platform (e.g., Wulf et al., 2003), and golf putting (Wulf et al., 1999).

However, there is also a substantial portion of attentional focus research that does not align with the predictions of OPTIMAL theory. For example, some studies have shown that external focus advantages in acquisition dissipate in subsequent retention tests (e.g., Carpenter et al., 2013; Fairbrother & Woodard, in preparation). Other research has shown enhanced learning *without* the presence of immediate performance benefits for externally instructed groups (e.g., Chiviacowsky, Wulf, & Avila, 2012; Hadler et al., 2014). Still other studies have demonstrated null effects, such that groups instructed to focus externally do not outperform internal focus groups or control (no focus instruction) groups in acquisition or retention (e.g., Lawrence et al., 2011; Perreault & French, 2016). These findings indicate that the predictions of OPTIMAL theory are not sufficiently robust to account for all situations and highlight the theory's failure to account for the full body of attentional focus research.

Statement of the Problem

Potential explanations for the inconsistent findings within attentional focus and motor learning research have yet to be fully explored. Researchers have often pointed to non-compliance with instructed foci to explain unexpected results (e.g., Post, Barros, et al., 2011). However, this explanation does not account for all discrepancies, as several studies have failed to demonstrate external focus effects in acquisition or retention even though participants reported compliance (e.g., Chua et al., 2018; Fairbrother & Woodard, in preparation; Lawrence et al., 2011). Another factor to consider may be the manner in which focus cues are delivered, as results have varied in ways that might be attributed to such differences. For example, most of the existing studies showing clear external focus instruction effects on learning have relied on repetition of a single focus cue (e.g., Chiviacowsky, Wulf, & Avila, 2012; Totsika & Wulf, 2003; Wulf et al., 1998). This approach has been used in studies showing effects after brief acquisition phases, but not in some studies involving more extensive practice phases (e.g., Carpenter et al., 2013; Poolton et al., 2006, experiment 1). Additionally, repetitive cueing is not consistent with many real-world instructional constraints and directly contradicts recommendations from other research showing that learning is enhanced through the provision of self-control over aspects of the instructional setting (e.g., Aiken et al., 2012; Chiviacowsky & Wulf, 2005). Some researchers have tested more realistic instructional approaches, either providing multiple focus cues in an *instructional set* at the start of practice (e.g., Poolton et al., 2006, experiment 2) or tailoring multiple internal and external cues to fit each learner's specific needs throughout practice (e.g., Perreault & French, 2015). Some of these studies have failed to support the prediction that external focus instructions should enhance learning (e.g., Rivadulla et al., 2018) while others have provided only partial support for this prediction (e.g., Tsetseli et al., 2016). Evidently, the beneficial effects of external focus instructions may be mitigated by extensive practice or by realistic instructional approaches revealing a need to determine more robust attentional focusing strategies.

In contrast to the relatively simple cue structures used in most experimental research, experts have repeatedly reported adopting varied, multidirectional, and abstract focus cues (Bernier et al., 2016; Fairbrother et al., 2016). The use of varied foci is consistent with traditional models of the stages of learning (Fitts & Posner, 1967; Gentile, 1972). These models suggest that learners' attentional allocation will naturally shift throughout the skill development process, although they do not specifically address how this attentional shifting may fit into the internal and external focus framework. Since experts have undeniably achieved success, it seems reasonable that their varied tactics for managing attentional focus could be used to develop effective attentional cueing strategies for other learners. In initial observations and tests of this idea, it will be helpful to restrict the examination of experts' strategies to the internal and external focus framework, thus allowing for a comparison with existing recommendations from the attentional focus literature. Another facet of such a comparison is that experts often engage in solo practice (Ericsson et al., 1993), giving them the freedom to choose their own focus strategies rather than adopting foci which are imposed by an external party. This stands in contrast to recommendations from OPTIMAL theory and from previous attentional focus research which posit that performers should be compelled to adopt external foci in all situations. Therefore, initial exploration will benefit from comparisons of experimenter-controlled internal and external instructions with approaches based on experts' attentional focus strategies (e.g., a predetermined schedule incorporating attentional shifts). It will also be fruitful to include a comparison condition wherein participants self-select attentional cues from options derived through examinations of experts' approaches. A logical first step will be to test these approaches in a near expert population, as they presumably share many common attributes with experts. Future research may then extend this test to less skilled populations.

Purpose of the Study

The purpose of the current research was therefore two-fold. The purpose of the first study was to explore and document the self-reported attentional focus targets of expert jump rope athletes as they practiced novel jump rope skills. The purpose of the second proposed study was to determine whether or not instructional approaches based on experts' attentional focus strategies compared favorably with existing recommendations emerging from the attentional focus literature.

Hypotheses

Study 1. Due to the exploratory nature of Study 1, no formal hypotheses were tested.

Study 2. Based on the existing body of literature concerning attentional focus effects on and motor performance and learning, the following hypotheses will be tested:

If existing attentional focus recommendations are superior to those modeled after experts' strategies, the following results will be expected:

1. The external focus group (EF) will produce higher scores (i.e., complete more successful attempts) compared to the internal focus group (IF) during all practice sessions.
2. The external focus group (EF) will score similarly to the internal focus group (IF) during baseline but will produce higher scores compared to the IF group during the learning assessment.
3. The external focus group (EF) will produce higher scores compared to the expert modeled group (EM) during all practice sessions.
4. The external focus group (EF) will score similarly to the expert modeled group (EM) during baseline but will produce higher scores compared to the EM group during the learning assessment.
5. The external focus group (EF) will produce higher scores compared to the expert modeled-autonomous group (EM-A) during all practice sessions.
6. The external focus group (EF) will score similarly to the expert modeled-autonomous group (EM-A) during baseline but will produce higher scores compared to the EM-A group during the learning assessment.

If instructional approaches based on experts' attentional focus strategies are superior to existing recommendations, the following results will be expected:

1. The external focus group (EF) will produce significantly higher scores compared to the internal focus group (IF) during all practice sessions.
2. The external focus group (EF) will score similarly to the internal focus group (IF) during baseline but will produce significantly higher scores compared to the IF group during the learning assessment.
3. The expert modeled group (EM) will produce significantly higher scores compared to the internal focus group (IF) during all practice sessions.
4. The expert modeled group (EM) will score similarly to the internal focus group (IF) during baseline but will produce significantly higher scores compared to the IF group during the learning assessment.
5. The expert modeled group (EM) will produce significantly higher scores compared to the external focus group (EF) during all practice sessions.
6. The expert modeled group (EM) will score similarly to the external focus group (EF) during baseline but will produce significantly higher scores compared to the EF group during the learning assessment.

If autonomy is necessary for reaping benefits from experts' attentional focus approaches, the following *additional* results will be expected:

1. The expert modeled-autonomous group (EM-A) will produce significantly higher scores compared to the internal focus group (IF) during all practice sessions.
2. The expert modeled-autonomous group (EM-A) will score similarly to the internal focus group (IF) during baseline but will produce significantly higher scores compared to the IF group during the learning assessment.

3. The expert modeled-autonomous group (EM-A) will produce significantly higher scores compared to the external focus group (EF) during all practice sessions.
4. The expert modeled-autonomous group (EM-A) will score similarly to the external focus group (EF) during baseline but will produce significantly higher scores compared to the EF group during the learning assessment.
5. The expert modeled-autonomous group (EM-A) will produce significantly higher scores compared to the expert modeled group (EM) during all practice sessions.
6. The expert modeled-autonomous group (EM-A) will score similarly to the expert modeled group (EM) during baseline but will produce significantly higher scores compared to the EM group during the learning assessment.

Assumptions

1. Participants practiced and performed their chosen skills according to the highest degree of their capabilities throughout the duration of the study.
2. Participants in Study 1 clearly and accurately reported their attentional focus targets during the preparation and execution phases of each practice repetition.
3. Participants in Study 2 adhered to the instructed foci.

Delimitations

1. Participation was voluntary.
2. Study 1 included competitive jump rope athletes who were experts in Single Rope Freestyle.

3. Study 2 included competitive jump rope athletes who were near-experts in Single Rope Freestyle.

Limitations

1. Verbal and written reports may have yielded incomplete or misrepresented attentional focus targets in Study 1.
2. Although participants were screened and classified as *experts* or *near-experts* based on objective criteria, some participants in each classification may have been more experienced and more highly skilled than others.

Definition of Terms

Acquisition: The learning of a skill or behavior; refers to the practice or performance phase preceding retention and transfer testing in experimental research protocols (Schmidt & Wrisberg, 2008).

Attention: An individual's awareness related to perceptual, cognitive, and physical stimuli or activities (Magill, 2011; Schmidt & Lee, 2011)

Attentional Focus: Deliberate, effortful concentration on a particular stimulus or source of information (Magill, 2011).

Automaticity: Refers to reflexive motor performance which is unencumbered by conscious control attempts. Often characterized by high movement adjustment frequency and efficient muscular contraction patterns (Wulf, Shea, et al., 2001).

Autonomy Support: Behaviors or conditions (e.g., the provision of choice) which give the learner either actual or perceived control over aspects of their practice environments. Posited to facilitate motor performance and learning in OPTIMAL Theory (Wulf & Lewthwaite, 2016).

Constrained Action Hypothesis: Proposes an explanation for the differential effects of internal and external focus on motor performance. Namely, the hypothesis states that focusing internally hinders performance by disrupting natural motor control processes. Focusing externally is posited to enhance performance by allowing the motor system to naturally exploit automatic control processes (Wulf, McNevin, et al., 2001).

Enhanced Expectancies: A learner's beliefs or expectations regarding their potential for achieving positive performance outcomes in the future. Posited to facilitate motor performance and learning in OPTIMAL Theory (Wulf & Lewthwaite, 2016).

External Focus Instructions: Cues or statements intended to direct a performer's attention toward the *effects* of their movements on the environment (Wulf et al., 1998).

Internal Focus Instructions: Cues or statements intended to direct a performer's attention toward their own movements (Wulf et al., 1998).

Motor Learning: Refers to a relatively permanent change in an individual's underlying capability or potential for executing a motor skill. In research protocols, motor learning is measured after the experimental manipulation has been removed, typically during retention and transfer tests (Magill, 2011).

Motor Performance: Refers to the immediately observable quality of skill execution. In research protocols, motor performance is typically measured in the presence of the experimental manipulation (e.g., an attentional focus instruction) (Magill, 2011).

OPTIMAL (Optimizing Performance Through Intrinsic Motivation and Attention for Learning) Theory: Proposed by Wulf & Lewthwaite as a framework for predicting and understanding motivational and attentional influences on motor performance and learning. The theory posits that an external focus of attention, autonomy support, and enhanced expectancies work to promote goal-action coupling, thus leading to improved performance and learning (Wulf & Lewthwaite, 2016).

Retention: Refers to the preservation of motor skill quality following a period of rest. In research protocols, retention tests are used to measure learning and are usually conducted after a period of rest following the acquisition phase. Retention tests require participants to perform the practiced motor skill under the same parameters that were used in acquisition (Magill, 2011; Schmidt & Wrisberg, 2008).

Transfer: The change in an individual's capability to perform a motor skill following exposure to a different skill or different version of the skill. In research protocols, transfer tests are used to measure learning and are usually conducted following retention tests. Transfer tests require participants to perform the practiced motor skill under different parameters than those used in acquisition (Schmidt & Wrisberg, 2008).

CHAPTER 2

Review of Literature

For centuries, philosophers and scientists have sought to understand the complexities of human attention. Early exploratory methods of observation and introspection led to a rather vague, yet foundational understanding of attention as a constituent of conscious awareness. More recently, scholars have taken an increasingly experimental approach, seeking to understand the nature of attention in relation to human experience and behavior. Of particular interest to scientists in the field of motor behavior is the body of research that examines the complex relationship between attentional processes and the performance and learning of motor skills.

Attention as a Limited-Capacity Resource

The current understanding of attention bears underpinnings from historical views in that attention is still conceptualized as one's awareness related to perceptual, cognitive, and physical stimuli or activities (see Kramer, et al., 2006; Magill, 2011; Schmidt & Lee, 2011). Most researchers also agree that attentional capacity, or the pool of resources available to handle stimuli and information, is inherently limited. Dual-task research protocols and reaction time paradigms have provided insight into the nature of capacity limitations and the attentional requirements associated with task execution (e.g., Pellechia, 2003; Tombu & Jolicoeur, 2003; Welford, 1952). Barring any structural interference, the degree of performance deterioration under dual-task conditions or reaction time delay under multiple-signal conditions is thought to provide information about competition for attentional resources that is induced by the paradigm. Several perspectives have been forwarded to explain this competition and the selective allocation of attentional resources for task performance.

Common views related to attention and performance are rooted in the information processing perspective. This perspective suggests that three distinct stages of processing are involved in skilled movement and effective interaction with one's environment. These stages include identifying stimuli, selecting an appropriate response, and programming the selected response (Donders, 1868/1969; Sternberg, 1969). Early and still well-accepted theories of attentional limitations, collectively known as "filter theories," have proposed that multiple stimuli can be processed in parallel during certain stages, but not in others (e.g., Deutsch & Deutsch, 1963; Keele, 1973). Parallel processing allows multiple signals to be processed simultaneously without inducing interference or overloading attentional resources (Schmidt & Lee, 2011). Most theorists have agreed that multiple stimuli can be detected and identified in parallel, but that a virtual filter or "bottleneck" exists at some point later in the processing stages (see McCann & Johnston, 1992 for a discussion). When signals reach this hypothetical filter, they can no longer be processed in parallel, and must be processed sequentially (McCann & Johnston; Schmidt & Lee).

Evidence also suggests that the detection of irrelevant stimuli can interfere with subsequent stages of information processing. Perhaps the most well-known demonstration of this type of interference is known as the Stroop effect (Stroop, 1935). In traditional studies of this phenomenon, participants are shown the names of various colors and are asked to say aloud the color of ink in which each name is printed. Results have consistently demonstrated that when the name of a color is written in an incongruent ink color (e.g., the word "red" written in blue ink), participants' responses are slower and more error-prone, compared to trials in which the color name and ink are congruent (for a review see MacLeod, 1991). A logical explanation for this phenomenon is that participants undergo attentional interference caused by unintentional processing of irrelevant information (i.e., semantic processing of the written color name). This irrelevant signal is processed in parallel with relevant information (i.e., ink color) during the stimulus identification stage, apparently inducing competition for attentional resources during later stages of processing. Applied to filter theories of attention, these results imply that, although parallel processing may occur freely in early information processing stages, it may lead to subsequent performance decrements due to interference in later stages.

While perspectives on human attention are broad and varied, extending far beyond the scope of the present review, consistent support exists for several fundamental characteristics of attention. Namely, evidence clearly demonstrates that attentional capacity is limited and that complex interactions between parallel and serial processing are involved in managing these limited capacity resources.

Attention and Motor Control

The human body's fascinatingly extensive degrees of freedom and the complexities involved in their coordination have given rise to much research and inquiry. Successfully organizing these degrees of freedom to produce skilled movement requires an intricate interplay between cognitive, sensory, and motor systems, involving both reflexive and conscious modes of control (Bernstein, 1996). Bernstein describes this complex coordination as "an inexhaustible flow of miracles lavishly presented to our eyes" (p. 85). As a tangible illustration of the complexities governing skilled movement, research has demonstrated that variations in muscle activation or joint position early in rapid movements are often accompanied by background corrections, allowing the skilled performer to accomplish their ultimate movement goal (e.g., Roberts & Lawrence, 2019). For example, a discrepancy between the intended and actual movement trajectory during a reaching task will often be instinctively and rapidly corrected so that the performer can effectively reach the target. These background corrections are apparently automatic and often undetectable to the mind of the performer (Bernstein).

Foundational to understanding skilled motor performance is the assumption that attentional capacity is limited, and thus the human brain cannot possibly allocate sufficient attentional resources to consciously control *all* the coordinative processes necessary for effective movement (for a discussion see Kahneman, 1973; Pashler et al., 2001). This idea has led researchers to investigate ways in which performers should allocate available attentional resources to support automatic control processes. Traditional views hold that focusing on the ultimate goal of an action, rather than the details of the action itself, leads to superior performance in skilled performers (e.g., Cattell, 1893). Early conceptualizations of this idea were presented in the ideo-motor theory, originating from the work of 19th century scholars (e.g., Harleb, 1861; James, 1890; Lotze, 1852, as cited in Koch, Keller, & Prinz, 2004). The ideo-motor theory posits that a bidirectional relationship exists between human actions and the inherent sensory consequences of those actions (Koch, et al.). It is thought that a performer's association between an action and its effect is strengthened through repeated experience, such that response effects become integrated into the performer's cognitive representation of the action. Once this association is established, directing attention toward the intended response effect (i.e., sensory consequences of action) should lead to a natural activation of the motor processes necessary to produce the effect (Stock & Stock, 2004). These ideo-motor concepts have been recently echoed in the action-effect principle (Prinz, 1997), which proposes that the representation of an action's effect aids in the performer's planning and control of that action.

Current Research on Attentional Focus

Reminiscent of the ideas of the ideo-motor theory and action-effect principle, a substantial amount of modern research has been dedicated to examining the relative effects of focusing one's attention toward movement effects versus movement components. This line of research is rooted in early conceptualizations of attention (e.g., James, 1890) and recommendations for advantageous attentional control in competitive sport (e.g., Gallwey, 1974). Within this recent body of work, attentional focus has been represented and studied in the context of two distinct categories, namely internal and external focus. This categorical representation of attention emerged from the research of Wulf and colleagues (for a review, see Wulf, 2013). An internal focus (IF) implies that attention is directed toward the performer's own body movements, whereas an external focus (EF) involves directing attention toward the *effects* of one's movements on the environment (Wulf et al., 1998). For example, in the context of balancing on an unstable surface (e.g., a stabilometer), focusing on the movements of the feet versus the movements of the surface would constitute internal and external foci, respectively. Over the past two decades, repeated experiments have tested the relative effects of IF and EF instructions on motor performance and learning.

As EF instructions tend to align with the idea of action effects in the ideo-motor theory and action-effect hypothesis (see Prinz, 1997; Stock & Stock, 2004), as well as with the general suggestions of Cattell (1947) and Bernstein (1996), it would be logical to expect superior performance under these instructions compared to IF instructions. Further, this expectation should be strongest for performers who have at least some level of experience with the experimental task or similar tasks, as this experience would presumably create an association between the performer's movements and the intended action effects (Koch, et al., 2004). These expected benefits have, in fact, emerged under EF conditions in much of the attentional focus research, providing support for the idea that focusing on one's intended goal is more effective than focusing on specific movement components.

Constrained Action Hypothesis

The performance benefits associated with EF instructions have been specifically explained by the Constrained Action Hypothesis (Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001). According to this hypothesis, focusing on movement effects (i.e., externally) is thought to enhance performance by allowing the motor system to naturally exploit automatic control processes, unencumbered by conscious control attempts (Wulf, McNevin, & Shea). Focusing internally, however, is posited to hinder skilled movement by disrupting these natural control processes. Three primary lines of evidence have provided support for the Constrained Action Hypothesis (CAH). Namely, an external focus of attention has been associated with an increased frequency of movement adjustments, decreased muscular activity, and apparent reductions in attentional resources required for task execution. Each of these lines of evidence will be reviewed in the following sections.

Adjustment frequency and movement fluency. Movement pattern variability is thought to be an indication of advanced levels of movement organization (see Newell & Slifkin, 1998). According to Wulf, McNevin, and Shea (2001) and McNevin et al. (2003), movement variability indicated by high frequencies of low-amplitude movement adjustments, is characteristic of skilled performance and coherence between reflexive and conscious modes of control in static tasks, whereas low variability indicated by lower adjustment frequencies is associated with increased conscious control and reduced efficiency. Within the context of attentional focus, several studies have demonstrated that EF instructions lead to higher adjustment frequencies compared to IF instructions. Wulf, McNevin, and Shea (2001) and Wulf, Shea, and Park (2001) were the first to report this finding, showing that participants who learned a balancing task under instructions to focus on the platform (EF groups) had higher adjustment frequencies during retention testing compared to those who were instructed to focus on their own feet (IF groups). These findings were corroborated in a similar study (McNevin et al., 2003) demonstrating again that movement adjustment frequencies were enhanced for participants in EF groups. Results also showed that this advantage was more pronounced for groups who focused on targets which were farther from their own bodies, thus supporting earlier contentions that actions are efficiently planned and controlled based on their remote effects (e.g., Hommel et al., 2001).

A study examining balance and automaticity in elite-level acrobats (Wulf, 2008) revealed results which contradicted those observed in novice performers. Namely, these expert acrobats displayed more automatic control characteristics under their normal focus conditions compared to conditions in which they were instructed to focus externally. These results provide some indication that EF instructions may produce differential responses in expert and novice populations.

Fluency of movement provides a useful measure of automaticity in the performance of dynamic motor skills (Roerdink, Hlavackova, & Vuillerme, 2011; as cited in Kal, van der Kamp, & Houdijk, 2013). Kal and colleagues tested the effects of focus instructions on this movement characteristic using a task which involved repeated flexion and extension of the lower leg. They found that movement fluency was significantly enhanced under EF conditions compared to IF conditions, providing support for the Constrained Action Hypothesis in the context of a dynamic motor task.

Muscular activity. Related to the conceptual advantages of high-frequency movement adjustments is the assumption that increased automaticity should be accompanied by more efficient co-contraction between agonist and antagonist muscles. According to the predictions of the Constrained Action Hypothesis, an external focus of attention should enhance this coordinative efficiency compared to an internal focus, leading to lower muscular activity without associated decrements in resultant force output or movement effectiveness.

This expected pattern has emerged across several studies and in a variety of experimental tasks. For example, Lohse et al. (2010) found lower integrated electromyography (iEMG) activity for the agonist muscle (i.e., tricep) in a dart throwing task under EF conditions. Decreased agonist activation, along with greater accuracy and sustained movement velocity demonstrated that co-contraction efficiency was indeed enhanced under EF compared to IF conditions in this study. Similar results have been found in other tests of dart throwing (Hitchcock & Sherwood, 2018), as well as in basketball free throw shooting (Zachry et al., 2005), and vertical jumping (Wulf, Dufek, et al., 2010). Lohse and Sherwood (2012, experiment 1) also found greater co-contraction of agonists and antagonists when participants were asked to focus internally during force precision tasks. This increased co-contraction was positively correlated with increased error, corresponding to decrements in both efficiency and movement effectiveness under IF conditions. Thus, studies on attentional focus and intermuscular coordination have consistently supported the CAH, providing evidence of heightened automaticity under EF compared to IF conditions.

Attentional requirements. Apparent decreases in attentional load under EF conditions constitutes the third line of evidence supporting the CAH. Researchers have indirectly tested the attentional demands of various experimental tasks through dual-task paradigms. For example, Wulf, McNevin, and Shea (2001) asked participants to perform a secondary reaction time task while balancing on a stabilometer. They found that participants in the EF group had shorter reaction times compared to those in the IF group, suggesting a greater availability of attentional resources associated with focusing externally.

Continuous secondary tasks have also been used to test attentional demands under distinct focus conditions. In one study, participants performed a continuous numerical task while riding a pedalo under speed pressure (Totsika & Wulf, 2003). As expected, the EF group demonstrated superior performance on the primary task (i.e., pedalo riding) compared to the IF group. Participants in Kal et al.'s (2013) study performed a continuous cognitive task in conjunction with the primary task (i.e., continuous leg flexion and extension) while focusing either internally or externally. Results of this study again showed that overall dual-task costs were greater under IF conditions. Interestingly, however, a significant interaction revealed that performance decrements occurred in the cognitive task rather than the primary motor task under IF conditions, whereas the opposite pattern occurred under EF conditions. These findings support the Constrained Action Hypothesis in that overall dual-task costs, and thus apparently overall attention requirements, were greater under IF instructions. However, they also reveal that the nature of the performer's focus seems to impact the relative priority placed on primary versus secondary tasks.

Poolton et al. (2006, experiment 1) examined task performance and attentional demands in golf putting. After learning the putting task with either IF instructions to focus on the hands or EF instructions to focus on the putter, participants were tested under single- and dual-task conditions. While performance did not differ between groups in the single-task retention test, the IF group's performance deteriorated with the addition of the secondary task in transfer. A follow up experiment by these same authors (2006, experiment 2) revealed divergent results when participants were given either multiple IF or multiple EF cues during practice. Namely, putting performance deteriorated significantly for both IF and EF groups under dual-task conditions, suggesting that the expected reduction in attentional demand with EF instructions may be mitigated by more complex instructional sets.

In general, the results of studies using dual task paradigms point toward reduced attentional demands associated with EF instructions compared to IF instructions. These findings, along with patterns of muscular activation and movement adjustment frequency, support the Constrained Action Hypothesis and its prediction that focusing externally promotes enhanced automaticity compared to focusing internally.

Immediate Behavioral/Performance Effects

While behavioral response measures do not provide direct tests of automaticity and the Constrained Action Hypothesis, they do allow researchers to explore the observable performance effects associated with attentional focus instructions. A substantial amount of research has demonstrated beneficial effects of EF instructions for immediate task performance. These effects have perhaps been shown most consistently in maximal power tasks such as the standing long jump (e.g., Becker et al., 2018; Wulf, et al., 2010). In an early test of standing long jump performance, Porter, Ostrowski, et al., (2010) found that participants jumped significantly farther when they were asked to focus on jumping past the start line (EF) compared to focusing on rapid knee extension (IF). Other researchers have asked participants to focus on jumping toward specific targets in EF conditions (e.g., Coker, 2016; Wu et al., 2012). These studies have also produced EF benefits, but the extent of these benefits seems to vary based on target distance and attainability. Specifically, increasing the distance of external targets tends to increase the benefit of focusing externally (Porter et al., 2012; 2013), but only to an extent (Westphal & Porter, 2013). According to Coker's (2016) results, the effectiveness of target distances may be individualized for each performer based on their own capability. Coker asked collegiate athletes to perform standing long jumps under two external conditions in which targets were situated at each athlete's previously recorded jumping distance (EF-attainable) or at a standardized, more distal location (EF-far). Results showed that participants jumped farther in the EF-attainable compared the EF-far condition. Coker suggested that this benefit may have arisen due to enhanced motivation or self-efficacy associated with focusing on an attainable target. A recent study produced further support for the efficacy of individualized target distances (Asadi et al., 2019). Specifically, results showed that allowing skilled and novice participants to choose their preferred target distances yielded performance benefits which were comparable to those in a standard EF condition.

Performers have also benefited from EF instructions in other maximal force production tasks such as vertical jumping (e.g., Wulf & Dufek, 2009; Wulf et al., 2007) and maximum isometric contraction (Halperin et al., 2016), as well as in tasks requiring high degrees of accuracy and precision. For example, participants have repeatedly performed more effectively on dart throwing tasks when they are instructed to focus on the flight of the dart or the dart board itself compared to specific bodily movements (e.g., Hitchcock & Sherwood, 2018; Marchant et al., 2007). Similar benefits have also been shown in basketball free throw shooting when participants focus on the basket versus their wrist motion (Zachry et al., 2005) and in field goal kicking when participants focus on the ball versus their own foot (Zachry, 2005).

Continuous task performance has also been enhanced under EF conditions. In a study on agility performance, for example, participants moved through a series of cones more quickly under EF versus IF conditions (Porter, Nolan, et al., 2010). Swimming performance was also enhanced when participants were instructed to focus on pushing the water back rather than pulling their hands back (Stoate & Wulf, 2011). Interestingly, although participants in this study performed equally well under EF and control conditions, follow-up analyses of questionnaire responses revealed that performers who chose to focus externally during the control condition outperformed those who chose to focus on internal stimuli. External focus instructions have also been associated with increases in time to exhaustion during isometric wall sitting (Lohse & Sherwood, 2011; Nolan, 2011), perhaps due to enhanced muscular contraction efficiency (see previous section for a discussion).

Alternative Findings and Special Issues

While the majority of evidence supports the widespread performance benefits of EF instructions, a few studies have yielded contradictory results. One of these studies examined golf putting performance under regular conditions and alternate conditions designed to induce distraction (Ziv & Lidor, 2015). The attentional focus instructions used in this study were comparable to those in previous research (e.g., Lawrence et al., 2012), and participants reported high levels of compliance with focus manipulations. However, no differences emerged between IF and EF groups in regular or distracting conditions. It is unclear why this investigation yielded unexpected results, but the authors speculated that perhaps the low skill level of participants contributed to the contradictory findings. The results of several other studies have shown that participants' expertise level may yield a significant influence on responses to attentional focus instructions (e.g., Couvillion & Fairbrother, 2018; Porter & Sims, 2013). These findings will be discussed in detail in a later section.

Older adult populations. The purported benefits of EF have not always been observed in older adult populations (e.g., Baniasadi et al., 2018; Chow et al., 2019). Baniasadi and colleagues asked a group of older adults to stand on a wobble board while holding a glass of water and found that postural sway was lower under a no-instruction control condition compared to the IF and EF conditions. Chow et al. compared the responses of younger and older adults to IF instructions in a similar balancing task. Interestingly, whereas younger adults displayed the expected performance decrements under IF conditions compared to baseline, older adults showed no such declines. Further, an analysis of neural responses revealed that performance declines in the younger participants may have resulted from increased communication between the verbal-analytical and motor planning areas of the brain. Older adults, however, showed no differences in brain activity between the two conditions.

Delayed effects. Occasionally, studies have only shown effects that emerged relatively late during the acquisition phase. For example, participants in Wulf, Shea, et al. (2001, experiment 1) practiced balancing on a stabilometer under both IF and EF conditions on the first day of practice and were asked to adopt their preferred focus on the second day. No differences were found between IF and EF conditions on either of these practice days, but an EF benefit did emerge on the third day when participants were free to direct their focus autonomously. Post-experiment interviews revealed that the majority of participants (i.e., 12 out of 17) chose to focus externally on day three, and these participants performed better than the five who chose an internal focus. Although intriguing, these results must be interpreted with caution. It is unknown whether participants *consistently* directed their focus internally or externally based on interview responses. More importantly, the protocol on day three does not allow for causal inferences, but rather the detection of an association between focus and performance. It is possible that participants who had achieved high levels of proficiency during the first two practice days had gained the confidence to relinquish conscious control and adopt an external focus of attention, thus leading to the appearance of an EF benefit on day three.

Delayed performance effects have also been shown in dart throwing and golf putting tasks (Lohse et al., 2014, experiment 1; Munzert et al., 2014). Similar to the aforementioned pattern of results, these investigations showed no EF effects early in practice. However, participants who focused externally during later trials performed more accurately than those who focused internally. The protocols used in these studies extended the results of Wulf, Shea, and Park (2001) in that focus direction was directly manipulated throughout practice, allowing for the detection of causal relationships between focus and performance late in practice.

These delayed EF benefits seem to align well with the predictions of Cattell (1893) and the ideo-motor theory (see Koch, et al., 2004). These authors suggested that focusing on action effects would be most logical and beneficial in the case that a connection between effects and corresponding movements had already been established. Perhaps EF participants in the aforementioned studies developed an association between external focus targets (i.e., action effects) and their own movement patterns throughout the study, resulting in benefits later in practice.

Summary of Important Findings: Attentional Focus and Motor Performance

As predicted by the Constrained Action Hypothesis, studies examining the relationship between attentional focus and motor performance have revealed widespread and consistent benefits of external focus instructions. These benefits have been demonstrated across a variety of measures, including assessments of movement adjustment frequency, muscle contraction patterns, attentional demand, and observable performance. Although alternate findings have emerged for participants of various ages and expertise levels, it is clear that in *most* situations, focusing on the effects of one's actions rather than on the actions themselves is advantageous for immediate motor performance. Future research should seek to determine the most effective types of EF cues for use in various contexts and the most effective methods for disseminating those instructions in naturalistic settings.

Performance Effects vs. Learning Effects

In addition to assessing immediate performance effects, a subset of research has been devoted specifically to examining the effects of internal and external focus instructions on motor *learning.* While motor performance only accounts for the immediately observable, and often transient quality of skill execution, motor learning encompasses relatively permanent changes in an individual's underlying capability or potential to execute a skill (Magill, 2011). In research contexts, motor learning must be inferred from observed performance in retention or transfer tests, during which any experimental manipulations (e.g., attentional focus instructions) are removed.

Research on attentional focus poses a unique challenge for deciphering between transient performance effects and the more permanent changes that are associated with true learning. Namely, while the attentional focus manipulations given during acquisition phases may be technically removed during retention and transfer tests (e.g., no focus instructions are given), it is always possible, and perhaps even likely, that participants will spontaneously adopt the experimental focus instructions during these tests. Therefore, performance during retention and transfer tests *may* indicate permanent changes in capability, or they may constitute another round of performance effects arising from the spontaneous adoption of a previously given focus cue. A small amount of research has attempted to address these two possibilities, but findings have not been conclusive. Lohse et al. (2014) demonstrated that the performance effects of focus instructions may tend to outweigh learning benefits that would be expected for participants who practiced under EF conditions. However, Totsika and Wulf (2003) found that participants who had practiced with EF instructions outperformed those in the IF group, even when they were given a secondary cognitive task that was designed to hinder the spontaneous adoption of acquisition foci. These authors, therefore, contended that focusing externally during practice does lead to enhanced learning rather than simply producing performance effects.

Mechanisms Underlying Potential Learning Effects

The Constrained Action Hypothesis provides a basis for explaining the benefits of EF instructions for immediate motor performance, but this hypothesis does not sufficiently explain mechanisms behind potential EF *learning* advantages. Recently, the OPTIMAL (Optimizing Performance Through Intrinsic Motivation and Attention for Learning) Theory has been proposed as a framework for predicting and understanding the learning advantages associated with an external focus of attention (Wulf & Lewthwaite, 2016). This theory suggests that, in general, conditions which facilitate intrinsic motivation and immediate performance outcomes will support the learning process. This assertion fails to account for a large body of research showing enhanced learning under practice conditions that yield immediate performance challenges and even detriments (for a review see Magill & Hall, 1990). Despite this body of research, OPTIMAL Theory posits that focusing externally will enhance learning primarily as a consequence of enhanced performance. Specifically, it is suggested that adopting an external focus of attention will facilitate goal-action coupling by directing attention toward the task goal and away from the self (or other “off-task” stimuli), thereby improving performance. These positive performance outcomes are said to promote “enhanced expectancies” for future outcomes, which in turn, trigger positive affect through dopaminergic responses, leading to memory consolidation and synaptogenesis. These processes are thought to facilitate motor learning. Notably, the theory also postulates that autonomy-supportive environments and other factors which promote enhanced expectancies will facilitate motor performance and learning through similar pathways.

Research directly examining the relationship between attentional focus and motor learning has produced some support for the OPTIMAL Theory's predictions, demonstrating enhanced performance and learning outcomes under EF conditions. However, other research has yielded findings that contradict the predictions of this theory. A few studies, for example, have revealed EF benefits during acquisition (i.e., immediate performance benefits) that subsequently fade in retention and transfer tests (e.g., Jackson & Holmes, 2011). Other studies have demonstrated the opposite pattern of results, showing advantages for EF groups in retention and/or transfer tests but not in acquisition (e.g., Lawrence, et al., 2012; Wulf et al., 1998, experiment 2). A third class of findings has shown no differences between IF and EF groups during either acquisition or testing (e.g., Coker, 2019; Lawrence et al., 2011; Stambaugh, 2019). Thus, the predictions of the OPTIMAL Theory have not been universally supported in empirical research.

It is plausible that research has only partially supported the OPTIMAL Theory because it only provides a partial explanation of the mechanistic pathways responsible for motor learning. Specifically, while this theory emphasizes the motivational and learning advantages of experiencing consistently "good" practice trials, other perspectives have noted the learning benefits of experiencing challenge (Guadagnoli & Lee, 2004) and even reasonable amounts of error during practice (e.g., Lee et al., 2016). Additionally, Schema Theory, a well-accepted theory of motor learning, posits that learning occurs by strengthening a performer's relationships between bodily movements, outcomes, and associated sensory consequences (Schmidt, 1975). According to the predictions of Schema Theory, practicing many variations of a given skill and thus experiencing a wide variety of movement outcomes will enhance the learner's cognitive representation of that motor skill, thereby augmenting learning effects (Schmidt & Lee, 2011).

Based on the aforementioned perspectives, it is plausible that exclusively adopting an external focus of attention may actually hinder learning to the extent that it prevents the learner from experiencing challenge, error, and outcome variability. Further, it may be that adopting a strategic, combined focus approach, including both internal and external foci, would provide a more optimal balance between challenge and success during practice, thus supporting both motivational and cognitive aspects of learning. The current body of empirical research has primarily focused on the effects of singular attentional approaches. Thus, future investigations on the effects of combined focus regimens may be necessary for refining the existing understanding of optimal motor learning conditions.

Research Examining Attentional Focus Effects on Motor Learning

This section will present findings related to the effects of internal and external focus instructions on motor learning in the contexts of discrete, serial, and continuous tasks. As previously discussed, it is difficult to ensure that learners will not spontaneously adopt experimental focus instructions during retention and transfer testing. The majority of research on attentional focus and motor learning, therefore, contains methodological challenges which may cloud interpretations. However, this body of research does provide valuable insight into (at least) extended performance effects and constitutes an initial platform for understanding the learning effects associated with attentional focus instructions.

Discrete Tasks

Aiming. Aiming tasks, such as throwing, striking, and shooting are frequently used as platforms for comparing internal and external focus effects. The majority of studies on these tasks have employed traditional, tightly controlled protocols involving repetitive dissemination of well-matched IF and EF instructions. These types of investigations have typically yielded findings which support EF learning benefits. For example, Chiviacowsky, Wulf, and Avila (2012) asked participants to practice tossing a beanbag to a target while focusing on either the movement of their throwing arm (IF group) or the movement of the beanbag (EF group). While groups did not differ from one another in practice, the EF group performed more accurately than the IF group in retention and transfer tests, suggesting a learning benefit, or perhaps a delayed onset performance effect stemming from spontaneous adoption of EF instructions during testing. Other studies with comparable instructional protocols have demonstrated similar benefits of EF instructions in golf putting, tennis forehand strokes, and handgun shooting (Brocken et al., 2016; Hadler et al., 2014; Raisbeck & Diekfuss, 2017; Wulf et al., 1999; Wulf & Su, 2007, experiment 1).

Other studies with similarly controlled manipulations have yielded mixed results. In one such study, participants learned a golf putting task with repetitive reminders to focus on the "swinging motion of the club/their arms" (EF and IF groups, respectively) (Lawrence, et al., 2012). No differences between groups were shown during either acquisition or retention testing. Marginal EF benefits emerged during a high-anxiety transfer test such that the EF group displayed improved performance, whereas the IF group simply maintained their retention performance levels. Notably, the control group (no focus instructions) experienced a significant deterioration in putting performance under pressure, suggesting that both IF and EF instructions provided a sort of protective mechanism against performance decrements. This finding is consistent with the idea that intentionally focusing attention is helpful for avoiding distractions and irrelevant sources of information (Singer, 1988). Deliberate allocation of attentional resources would have been particularly necessary during the transfer test in Lawrence et al.'s study, as attentional capacity was likely narrowed under pressure (see Arent & Landers, 2003). Comparable results emerged in Poolton et al.'s (2006, experiment 1) study. Groups again performed equally in both acquisition and retention, but on a dual-task transfer test the IF group experienced significant performance decrements while the EF group maintained performance levels. The dual-task protocol likely decreased the availability of attentional resources, and thus, between-group differences may have emerged due to differences in attentional demands induced by the internal and external focus instructions.

While the protocols of the aforementioned studies were all very tightly controlled, involving the use of simple, well-matched focus instructions, other investigations have used more complex designs. For example, Poolton, et al. (2006, experiment 2) gave participants in each group a series of six focus instructions while practicing a golf putting task. Results of this study yielded no differences between IF and EF groups in acquisition, retention, or transfer tests, perhaps due to the increased attentional demand placed on both groups through the addition of multiple cues. Tsetseli et al. (2016) employed a similarly complex design. Participants in this study were given sets of internally or externally framed focus cues to use as they practiced tennis skills over the course of several weeks. While no performance differences were found between groups, the EF group displayed better decision-making during retention testing compared to the IF group. The multiple-cue protocols used in these studies are arguably more realistic than traditional, single-cue designs. That is, learners are likely to be given more than one instruction during realistic practice sessions, so research involving multiple focus cues arguably provides a more realistic view of potential real-world effects.

Aiming tasks have also been used to explore the effects of instructor-selected feedback cues. In these investigations, participants are typically given feedback statements based on their performance needs which are designed to direct attention either internally or externally. For example, Wulf et al. (2002) provided internally- and externally-framed feedback to participants who were learning a tennis serve (experiment 1) and a soccer kick (experiment 2). Those receiving EF feedback displayed superior accuracy in acquisition and retention compared to their IF counterparts in both experiments. In a more recent study, however, children were given feedback statements such as, "Snap your wrist when releasing the ball," (IF group) or "Try to make the ball spin backward when you release it," (EF group) while learning to shoot a basketball (Perreault & French, 2016). Results of this study demonstrated EF benefits only in the final blocks of practice and retention. A manipulation check also revealed that the feedback statements were only marginally effective in directing the children's thoughts. Interestingly, Wulf, Chiviacowsky, et al. (2010) demonstrated that children who were given EF feedback outperformed those who were given IF feedback, but only when feedback was given after every single practice trial. The results of these studies seem to suggest that more frequent feedback is necessary to effectively direct children's focus and elicit EF benefits.

Other research has not supported the benefits of frequent EF feedback. A study by Agar et al. (2016) in which children were taught a shuffleboard task demonstrated no differences between groups, even though feedback was given after every practice trial. Furthermore, while frequent feedback *may* be more effective than occasional feedback for directing children's attentional focus, other lines of research have demonstrated negative effects of overly frequent augmented feedback on motor learning (e.g., Weeks & Kordus, 1998, Magill, 2011 The risks and possible benefits of frequent EF feedback must be considered equally when making decisions regarding instructional strategy. Further, the aforementioned results should cause researchers to consider whether attentional focus effects will reliably extend beyond laboratory settings for children, especially given the presence of inherent distractions and varying degrees of feedback availability in natural settings.

A final group of studies on aiming tasks has demonstrated that the length of practice phases may influence participants' responses to attentional focus instructions. Namely, when extended practice phases (e.g., more than 100 trials) have been implemented, results have been mixed. Some of experiments have yielded EF benefits during lengthy acquisition phases (Lohse et al., 2014, experiment 2) or during subsequent retention tests (Raisbeck & Diekfuss, 2017), while others have shown no differences between groups in either training or testing (e.g., Coker, 2019; Poolton, et al., 2006, experiment 2). Still other research has demonstrated EF benefits early in training which then faded after continued practice (Carpenter et al., 2013; Land et al., 2014). Given these discrepancies, more work is necessary to determine how focus instructions may impact performance and learning over long training cycles such as would occur in sport and other practical settings.

Overall, research has yielded some support for learning benefits associated with EF instructions and feedback in aiming tasks. However, these benefits are not universally supported and may not be robust to naturalistic instruction or feedback protocols (e.g., Agar, et al., 2016; Wulf et al., 2010), different populations (e.g., Emanuel et al., 2008; Perreault & French, 2016), or extended amounts of practice (e.g., Carpenter, et al., 2013).

Other discrete tasks. In addition to aiming tasks, researchers have explored the effects of attentional focus on several other types of discrete skills. Results of these studies have not produced conclusive evidence of EF learning benefits. For example, Post, Barros, et al. (2011) tested the performance and learning of a standing discus throw under internal, external, and neutral focus conditions. Participants' throwing technique and throwing distance were evaluated across practice and testing, revealing no differences between focus groups on either measure. Interestingly, responses on a post-training adherence check indicated that some participants adopted foci that were inconsistent with their group assignment. Some IF group members, for example, reported focusing on throwing the discus over an external target, and some EF group members reported focusing on internal goals such as shifting their weight or leading with their legs and trunk. Given this evidence of spontaneous focus shifting, the authors suggested that non-compliance may have contributed to the lack of between-group differences.

In a more recent study, participants learned a power clean, an Olympic weightlifting skill that requires precisely coordinated movement patterns to produce safe and effective performance (Rivadulla et al., 2018). Throughout practice, an experienced coach provided feedback statements which were based on each individual's performance and were specifically designed to elicit an internal or external focus of attention. Somewhat unexpectedly, results showed an *internal* focus benefit in one performance measure, namely, the distance between the bar and the lifter's center of mass during the drop phase. In all other phases and technique measures, the IF and EF groups displayed similar performance and similar improvements across the study. The results of this study indicate that IF cues are not always detrimental and can, in fact, be helpful for learning aspects of complex skills.

Studies on simpler tasks have produced distinct findings. Lohse (2012), for example, demonstrated an EF benefit for learning a simple force production task. This task required participants to plantar flex the ankle, exerting a specified amount of pressure on a force plate. Participants in the IF and EF groups were told to mentally focus on "the muscle in [their] calf," and "the push of [their] foot against the platform," respectively. This study demonstrated between-group differences in acquisition, retention, and transfer, such that the EF group performed more accurately in all three phases. However, it must be noted that the focus instructions used in this experiment likely introduced attentional confounds. Namely, the EF instruction to focus on the push of the *foot* against the platform may have partially directed attention internally, thus representing a combined focus on the connection between the body and the apparatus. Furthermore, this instruction also promoted the effective use of haptic feedback and was directly tied to the overall movement goal (i.e., exerting pressure against the platform), while the instruction given to the IF group did not afford these benefits. Participants in the IF group were told to direct their focus toward their calf muscle, potentially taking necessary focus away from other sources of internal information (i.e., haptic feedback in the sole of the foot and the other muscles involved in plantar flexion such as the flexor hallucis longus). Thus, the quality of the IF instruction was presumably inferior to that of the EF cue. A more direct comparison of internal and external foci may have been achieved with content-matched cues, such as "focus on exerting pressure on the platform" and "focus on exerting pressure with your foot."

Overall, experiments investigating learning in discrete, non-aiming tasks have produced mixed findings. Somewhat unexpectedly, the majority of these findings have not supported EF benefits, and one study demonstrated a partial IF benefit. Discrepancies between findings may have arisen due to compliance issues, task complexity, or perhaps due to differences in the quality of IF and EF instructions. Future researchers should pay particular attention to designing focus cues that vary only in terms of direction, rather than in quality.

Serial Tasks

Serial tasks are only occasionally represented in attentional focus literature. Accordingly, the effects of IF and EF instructions on these tasks are not well established or understood. While some research has shown the expected benefits of external foci, other studies have not supported these effects. One such study involved learning a simple gymnastics routine (Lawrence et al., 2011). The instructions given to participants were well-matched in content, differing only with respect to focus direction, and were specifically designed to address key aspects of gymnastics judging criteria. Retention and transfer tests showed no learning differences between IF and EF groups, and acquisition data revealed an unexpected EF focus detriment, such that performance of the EF group declined across the first half of acquisition.

Other studies on serial tasks have shown clear EF benefits in both acquisition and retention. For example, Lawrence et al. (2019) gave experts and novices a series of internally and externally directed focus cues as they practiced surfing routines. These focus instructions were fairly well matched; however, EF cues tended to be more clearly connected to optimal positioning and movement goals compared to IF cues. Participants in the EF group outperformed those in the IF group during acquisition and retention, supporting the presence of an EF learning benefit. Importantly, surfing routines were not pre-determined in this experiment. Rather, participants were given the freedom to choose their own skills. Because difficulty level was an important aspect of the judging criteria, it is possible that differences between IF and EF groups emerged due to differences in the difficulty of chosen skills, rather than differences in the quality of skill execution.

It is likely that the contradictory results obtained in the two aforementioned studies are the result of differing task characteristics (i.e. standardized gymnastics routines vs. participant-determined surfing routines) and judging criteria (i.e. skill execution only vs. difficulty level and skill execution). Additional research would be helpful to clarify the effects of focus instructions on serial tasks.

Continuous Tasks

Dynamic continuous tasks. Dynamic continuous skills such as jump rope, ski simulations, and locomotor tasks have been fairly well represented in attentional focus research. The majority of research using these tasks has shown EF instructions as advantageous. Additionally, most of these studies have included IF and EF instructions which are well-matched in terms of content and quality, allowing for direct comparisons between focus directions. For example, while learning to ride a pedalo (i.e., a standing, miniature cycle) participants in various studies have been instructed to focus on their feet/pushing their feet forward (IF groups) or on the platforms/pushing the platforms forward (EF groups) (Abdollahipour et al., 2019, experiment 2; Flores et al., 2015; Totsika & Wulf, 2003). Children, visually-impaired adults, and healthy adults in EF groups have consistently demonstrated superior performance and learning compared to those in IF groups. Similar results have been found using a ski simulator task (Wulf et al., 1998, experiment 1), such that participants who focused externally versus internally showed superior performance in both acquisition and retention.

Studies on jump rope tasks have produced somewhat conflicting results. Skilled participants in Porter et al.'s (2016) study displayed superior jump rope performance during acquisition, retention, and transfer tests when they practiced under EF conditions (i.e. focusing on rotating the handles) rather than under IF conditions (i.e. focusing on rotating the wrists). Slightly divergent results emerged for novice participants who learned to turn double dutch ropes under instructions to focus on the ropes or on their forearms. (Fairbrother & Woodard, in preparation). Participants in the EF group outperformed those in the IF group during acquisition, but this difference was eliminated in retention and transfer tests. It is possible that the visual salience of rope movements prompted both groups to spontaneously focus externally (i.e., on the ropes) during testing, regardless of their focus during acquisition. Notably, almost all participants in this study reported focusing on more than one type of cue, indicating that between-group differences were perhaps mitigated in retention and transfer testing due to spontaneous focus shifts.

Overall, the body of research investigating dynamic continuous tasks has supported the benefits of EF instructions. The majority of this research has featured well-matched focus instructions and controlled environments, allowing for clear interpretations of results. However, questionnaire responses have indicated the tendency of some participants to shift their focus during continuous task execution, suggesting the need for future research to examine refocusing techniques to facilitate shifting from internal to external foci.

Static continuous tasks. Studies examining the effects of attentional focus on balancing (i.e., static continuous) tasks have provided fairly convincing evidence of EF learning benefits. Although many investigations have not demonstrated advantages for EF participants during acquisition (e.g., Chiviacowsky et al., 2010; McNevin et al., 2003), benefits in retention tests have been fairly consistent. Most often, instructions for balancing tasks direct the learner's focus either toward keeping the feet level with each other (IF groups), or toward keeping two markers on the balancing apparatus level with each other (EF groups). These markers are usually situated directly in front of the feet, and thus the location of focus target varies by only a few inches. Verbal content is also well-matched, varying only by one or two words, such that instructional quality is virtually identical for IF and EF groups. Because of these similarities, differences observed between-groups is convincing.

Wulf et al. (1998, experiment 2) were the first to test IF and EF cues in a balancing task. Their results demonstrated enhanced performance during retention for the EF group, although acquisition performance did not differ between IF and EF groups. Since this experiment, several studies have used similar focus cues and provided additional support for the learning benefits of EF instructions (e.g., Chiviacowsky et al., 2010; Shea & Wulf, 1999.). Research has also demonstrated heightened EF benefits when markers are situated farther away from participants' feet (distal EF) compared to when they are situated directly in front of the feet (proximal EF). This augmented benefit, known as the "distance effect" was first demonstrated by McNevin et al. (2003). In this study, two distal EF groups demonstrated fewer errors in retention compared to the IF group, along with more automatic, reflexive movement patterns compared to the IF and proximal EF groups.

A few studies have examined alternative types of focus instructions for balancing tasks. For example, Wulf et al. (2003) sought to determine whether focusing internally or externally on a suprapostural task would affect primary task (i.e., balancing) performance. In a series of experiments, these researchers asked participants to balance on a stabilometer while holding a long tube in their hands. Participants were told to focus either on keeping their hands (IF group) or the tube itself (EF group) horizontal during balancing trials. Results showed that the EF group not only outperformed the IF group on the suprapostural task, but also on the primary balancing task. Somewhat surprisingly, this beneficial pattern was sustained in the primary balancing task, even when the pole was removed during transfer testing. The removal of the pole logically prevented participants from adopting their acquisition focus. Thus, these results have provided some of the most convincing evidence to date in support of true EF learning benefits.

The majority of research on balancing tasks has involved a fairly homogenous pool of participants, namely young, healthy adults. However, a few studies have tested alternate populations and yielded somewhat mixed results. For example, Thorn (2006) instructed children to focus on either "keeping [their] body still" (IF group) or "keeping the platform still" (EF group) during balancing trials. Initial analyses did not reveal any clear differences between IF and EF groups. However, after eliminating participants who did not report focusing on the instructed cue, EF benefits emerged. These results align with other research in young populations (e.g., Perreault & French, 2016), providing further evidence that the effects of focus instructions may not be as robust in children as in adult populations and that adherence to instructed cues may moderate effects. Thus, it is likely that other attention-directing techniques (e.g. visual feedback or more frequent focus reminders) may be necessary for producing reliable benefits in young participants.

It is also unclear whether EF instructions are effective for enhancing balance in older adult populations. Specifically, while one study demonstrated expected EF learning benefits in this population (Chiviacowsky et al., 2010), another experiment revealed no differences on any stability measures (Bruin et al., 2009). It is possible that methodological distinctions may have contributed to these conflicting findings. Specifically, Chiviacowsky et al. (2010) employed more straight-forward focus manipulation, repeatedly instructing participants to focus on keeping their feet (IF) or the markers (EF group) horizontal while balancing. Bruin et al. (2009), however, used a feedback protocol to manipulate focus direction. Visual feedback in the form of a moving red dot was presented to participants during practice trials. Participants were told that the dot represented either their body's center of gravity or a point on the balance board, to direct focus internally or externally, respectively. Based on the null results of this study, it seems plausible that the provision of concurrent feedback overrode the effects of attentional focus instructions. Furthermore, contrary to the simplistic practice regimens used in most attentional focus research, participants in this study were given a more realistic training protocol that involved a series of balancing exercises with gradually increasing complexity. The uniquely realistic nature of this experiment and others which have produced similar results (e.g., Tsetseli, et al., 2016) should prompt researchers and practitioners to consider whether naturalistic practice conditions may override or at least moderate the expected attentional focus effects.

Summary of Important Findings: Attentional Focus and Motor Learning

The effects of attentional focus instructions and feedback on motor learning appear to vary based on the experimental task, population, and instructional climate. With regard to experimental task, the expected benefits of EF instructions have been demonstrated most consistently in continuous skills. Findings in discrete and serial tasks have been much less predictable, producing several instances of equivalent learning between IF and EF groups (e.g. Agar, et al., 2016; Coker, 2019), and a few instances of superior learning under IF conditions (e.g. Lawrence, et al., 2011; Rivadulla et al., 2018).

Mixed findings have also been shown in different populations, with the most apparent distinction emerging between children and adults. Although research on adult populations has yielded mixed findings, the general trend in this population has pointed toward more effective learning under EF conditions (e.g., Lohse, 2012). The majority of studies exploring learning effects in children, however, have not demonstrated clear EF advantages. Some researchers have pointed toward low adherence to focus instructions as a potential reason for unexpected results (e.g., Thorn, 2006). Others have suggested that children may respond better to IF cues due to relatively underdeveloped levels of motor competency and difficulties performing under the automatic control that is associated with EF instructions (Emanuel et al., 2008; Wright, 2019).

Finally, the relationship between learning and focus direction has varied in studies with distinct instructional protocols. Highly controlled studies, involving repetitive dissemination of simple focus cues, have often yielded results that favor EF instructions (e.g., Totsika & Wulf, 2003; Wulf et al., 1998). However, protocols which mimic more realistic conditions, either through the use of multiple focus instructions or individualized feedback, have not consistently yielded EF benefits (e.g., Agar, et al., 2016; Bruin et al., 2009; Zentgraf & Munzert, 2009). The duration of practice may also influence focus effects, as lengthy practice phases have frequently been associated with null results in retention tests (e.g., Poolton, et al., 2006).

The current body of literature on attentional focus and motor learning has yielded some convincing, although inconsistent, evidence of EF learning benefits, and has arguably even produced general trend to this end. Further, evidence showing any learning advantages of focusing *internally* is scarce. With only rare exceptions (e.g., Rivadulla et al., 2018), groups who practice under IF conditions have either performed more poorly or equivalently to EF groups in retention and transfer testing. This pattern, along with the fairly common observation of EF benefits, has promoted the popular message that focusing externally is *always* advantageous, and there is therefore "no place" for IF instructions (see Abdollahipour et al., 2015). A thorough evaluation of current research, however, reveals that EF instructions do not always yield traditionally expected learning benefits, and IF instructions are not always detrimental. These atypical findings suggest that the relationship between focus instructions and motor learning is perhaps more complex than has been previously considered. In order to stimulate meaningful future research and guide practitioners toward optimal focus strategies, researchers must diligently explore the complexities of the attentional focus and motor learning relationship and examine potential factors underlying divergent findings.

Influential Factors and Practical Application

This section will present factors which may influence the effects of attentional focus on motor performance and learning. These factors will be discussed in light of the discrepancies in previous research and with an aim toward gaining insight into the complexities of attentional strategies.

Functional Consistency

Previous research has demonstrated that participants tend to perform relatively well on the specific task elements which are emphasized in their focus instructions. This principle was perhaps most clearly demonstrated in an experiment by Zentgraf and Munzert (2009) which required participants to learn a juggling task while focusing on the details of ball flight (EF group) or on arm and hand movements (IF group). Although groups did not differ with respect to overall task performance, each group displayed more advanced kinematics in the particular aspect of juggling that was emphasized in their focus instruction. Specifically, the IF group produced superior arm and hand kinematics, while the EF group produced superior ball flight kinematics. These findings fundamentally illustrate the importance of ensuring the specificity of focus instructions with respect to desired performance outcomes. Instructions which lack consistency with measured performance variables may direct attention inappropriately, causing the performer to emphasize less relevant task features and perform less effectively on measured objectives, thus impairing performance related to these variables. The majority of attentional focus research has involved tasks with performance measures that are inherently connected to external features. For example, frequently studied skills such as dart throwing, basketball shooting, and golf putting all carry the objective of reaching a specified external target. Based on the demonstrated importance of instructional specificity, the frequent use of these types of tasks may have biased previous results toward producing and repeatedly confirming EF benefits.

Inconsistencies between focus instructions and task objectives may also help to explain the increased attentional demands that have been associated with IF instructions. According to the Conscious Processing Hypothesis (Poolton et al., 2006), IF instructions excessively burden the working memory by requiring the performer to allocate attentional resources to both the instructed (internal) stimuli and the external stimuli which are important for task execution. In essence, if participants are at all committed to producing external outcomes, as is likely the case when researchers are measuring such outcomes, then focusing internally on specific body parts or movements will almost inevitably result in divided attention. Poolton and his colleagues (2006, experiment 1) demonstrated this concept using a golf putting task. The results of this study showed no difference in putting performance during acquisition or retention testing. However, under attentionally demanding conditions, performance deteriorated for the IF group who had focused on hand motions during practice but remained stable for the EF group who had focused on the putter head, suggesting that the IF instruction likely led to a heightened attentional resource need. Although neither group in this study was explicitly told to focus on the most salient task objective (i.e., successfully sinking the golf ball), the external instruction promoted a more functionally relevant focus than the internal instruction, in that the motion of the putter head (EF) directly influences ball trajectory. The IF instruction to focus on hand motions was much more loosely coupled to the outcome (e.g., correct hand motion combined with an incorrect putter alignment would yield poor results) and likely prompted participants to consciously attend to both internal and external information, thus inducing an increased information processing burden (see Poolton et al., 2007; Wrisberg, 2007).

Further research has suggested that not only *actual* consistency, but also *perceived* consistency, between the task goal and instructed focus may impact performance. Jackson and Holmes (2011) demonstrated the impact of perceived consistency by informing two groups of participants that success on a balancing task would be evaluated either based on foot movements or board movements, even though in reality, board movements were always used to measure performance. Half of the participants in each of these groups were then asked to focus internally or externally, creating two groups whose task objective and focus instruction were consistent and two groups whose objective and focus instruction were inconsistent. During acquisition, EF instructions were beneficial *only* for participants who were told that the board movements would be evaluated, thus creating consistency between the instructed focus and the perceived task objective. Further analysis revealed an effect of consistency such that the two groups with consistent foci and task objectives (i.e., IF with feet measurement and EF with board measurement) outperformed the inconsistent groups. This study highlights the importance of clearly communicating task objectives with learners and providing focus cues that are consistent with those objectives.

Other studies have examined balancing tasks using focus instructions that were virtually identical to those described above (e.g., Wulf, et al., 1998, experiment 2). Somewhat ironically, it has been argued that these instructions represent equivalent informational content and functional relevance to the task objective because they vary by only one or two words (e.g., feet vs. board). However, these studies have also featured subtle indications that board positioning would be used as the performance criterion measure (e.g., presence of a potentiometer on the stabilometer), likely yielding greater perceived congruence between instructed focus and task objective for the EF group. Based on the results of Jackson and Holmes' (2011) investigation this seemingly minor methodological detail may have biased results toward EF advantages.

Many other experiments have similarly neglected the importance of consistency between foci and task objectives. That is, measured performance variables have often been external in nature (e.g., movements of a ski simulator apparatus or a pedalo, motions of double dutch ropes, landing positions of golf balls or darts), and EF instructions have almost invariably featured high degrees of relevance to these objectives (e.g., Wulf, et al., 1998, experiment 1; Fairbrother & Woodard, in preparation, Lohse, et al., 2014). Internal focus instructions, however, have typically directed attention toward overly narrow, less obviously relevant aspects of task execution and have lacked direct connection to measured variables. These confounds have likely contributed to an incomplete picture of the advantages and disadvantages associated with EF and IF instructions in previous research. In fact, recent evidence has suggested that holistic IF cues which direct attention more broadly than traditional IF cues (e.g., feeling explosive while jumping) may be equally as effective for enhancing performance as EF instructions (Becker et al., 2019; Hebert & Williams, 2017).

Future research will be necessary to systematically test the impact of consistency between focus instructions and task objectives within IF and EF contexts. At present, we must consider the possibility that at least a portion of the existing research has simply demonstrated the importance of focusing on goal-relevant stimuli, rather than the importance of indiscriminately focusing externally. If this is the case, then practitioners should be advised to design focus instructions that are, above all, congruent with task objectives, instead of placing undue emphasis on avoiding internal foci. Furthermore, as goals and objectives shift across practice sessions, across drills, or even across repetitions, focus instructions should be altered accordingly. These principles warrant additional, focused research and careful consideration when advising practitioners.

Autonomy Support in Attention Focus Research

Supporting perceptions of autonomy during the learning process has become a hallmark of effective instruction. Autonomy, or a sense of control over one's actions and decisions, has been identified as a "basic psychological need" and is a foundational component fostering intrinsic motivation (Duda & Treasure, 2015; Ryan & Deci, 2000). A large body of research has also demonstrated that motor learning is significantly enhanced when learners practice in autonomy-supportive environments rather than in controlling environments (for a review see Sanli et al., 2013). Accordingly, the OPTIMAL theory specifically emphasizes the importance of using autonomy-supportive language and providing choices during practice for promoting motor learning (Wulf & Lewthwaite, 2016).

OPTIMAL theory suggests that autonomy support and an external focus of attention work through similar pathways to facilitate motor performance and learning (Wulf & Lewthwaite, 2016). Somewhat paradoxically, however, the nature of most attentional focus research protocols may actually thwart learners' perceptions of autonomy. Focus instructions are often given in a manner that communicates obligatory compliance (e.g., "Focus as hard as you can on this cue during the entire sprint.") (Winkelman et al., 2017) rather than self-determined compliance. Additionally, as previously discussed, many protocols have involved repetitive dissemination of focus cues which lack consistency with task objectives, particularly for IF groups. These conditions risk thwarting perceptions of autonomy, particularly if participants are aware that the instructed cue is irrelevant or ineffective. In such cases, repetitive commands to focus on the unhelpful cue may undermine participants' perceptions of causality or autonomy over their performance outcomes, thus degrading motivation and impeding performance and learning. Alternatively, participants may choose not to comply with the instructed foci (e.g., Post, Barros, et al., 2011), perhaps in an effort to preserve their own autonomy. As such, the results of much existing attentional focus research may be confounded by a lack of autonomy support, leading to non-compliance or unmatched motivational climates between IF and EF groups.

A few studies have used alternate protocols that involve the provision of multiple attentional focus cues. These cues are typically given either as an instructional set at the beginning of practice (e.g., Poolton et al., 2006, experiment 2) or individually at periodic times based on each learner's particular needs (e.g., Becker & Fairbrother, 2019). The former method may enhance perceptions of attentional autonomy, as learners are essentially able to decide which of the cues in the instructional set they will focus on during each practice trial. The latter method may serve to equate cue relevance across groups as learners are given instructional cues which are deemed to be appropriate for their trial-to-trial performance needs. Thus, each of these instructional designs addresses one of the problems of traditional attentional focus research discussed above. Interestingly, some of these multiple-cue protocols have produced equivalent learning for IF and EF groups (e.g., Agar et al., 2016; Rivadulla et al., 2018; Tsetseli et al., 2016), suggesting that some of the EF advantages seen in previous research may have been partially related to differences in perceived autonomy and related motivational factors. Further, because multiple-cue protocols are arguably more consistent with real-world instructional settings, these results raise some doubts about the generalizability of traditional EF advantages to realistic training environments. Future research should explore the effects of more direct autonomy manipulations within the contexts of internal and external attentional strategies.

Long Term Effects

A large portion of the existing attentional focus research has involved very brief acquisition phases, often consisting of fewer than 100 practice trials spanning one to three days. Although these brief protocols commonly produce EF benefits, studies with more lengthy practice phases have produced mixed results, suggesting that the traditionally observed advantages of EF instructions may be mitigated by extended amounts of practice. For example, Bruin et al., (2009) implemented a five-week (10-session) balance program in an older adult population and found no differences between IF and EF groups for performance or learning. A brief, 1-day balancing intervention, however, yielded EF learning benefits in a similar population. An intermediate length (7-day) balance intervention yielded temporary advantages for the EF group in acquisition, but these benefits were eliminated in retention testing (Diekfuss et al., 2019).

Discrepancies have also been observed between studies on discrete tasks, such that most experiments involving extensive practice phases have yielded no group differences in retention (e.g., Poolton et al., 2006), whereas shorter practice phases have often been followed by EF benefits in testing (e.g., Brocken et al., 2016; Hadler et al., 2014). These distinct patterns of results demonstrate that the traditional benefits of EF instructions may not be robust to the extensive training regimens that are used in sport and other practical settings. Specifically, the learning benefits of focusing externally may become less pronounced as learners gain proficiency.

Attentional focus across the learning process. It has been suggested that optimal focusing methods may shift as performers undergo prolonged training and progress through stages of learning. For example, Maurer and Zentgraf (2007) proposed that while external foci may be appropriate for helping learners develop a general representation of the task in early learning stages, IF instructions designed to emphasize interoceptive feedback sensations may aid in subsequent skill refinement. There is a need for research to determine how focus cues should be adapted and progressed to provide continued benefits across weeks, months, and even years of training. Although studies have not yet examined this topic directly (e.g., through longitudinal attentional manipulations), cross-sectional examinations of expert and novice performers along with experts' reports of their own attentional strategies may provide some insight into distinct attentional needs across the learning process.

Comparing expert and novice responses to attentional focus instructions. Interesting distinctions have emerged in attentional focus research comparing novice and expert populations. While a few investigations have shown similar EF benefits in both skilled and novice participants (Wulf & Su, 2007; Wulf et al., 2002), other studies have shown that responses to attentional focus instructions tend to differ across levels of expertise (e.g., Couvillion & Fairbrother, 2018; Winkelman et al., 2017).

In a study examining jump rope performance (Couvillion & Fairbrother, 2018), expert jump rope athletes performed most effectively in baseline and broad EF conditions (i.e., focus on jumping sounds), whereas novice performance was enhanced when they focused on their wrists or rope handles but degraded when they focused on their feet or on jumping sounds. Interestingly, no focus instructions *enhanced* expert performance relative to baseline, and an external focus of attention was not directly beneficial even for novices. Rather, novices excelled under both IF and EF cues which directed attention toward the most difficult aspect of the task (i.e., controlling the rope). This pattern aligns with other results showing that novice performers tend to benefit from instructions emphasizing a "skill focus," regardless of whether these instructions are externally or internally directed (e.g., Castaneda & Gray, 2007; Perkins-Ceccato et al., 2003).

Castaneda & Gray (2007) investigated batting performance in low- and high-skilled participants. Across four conditions, participants' attention was directed toward their hand movements (skill/IF condition), bat movements (skill/EF condition), on the ball leaving the bat (environmental/EF condition), or on an auditory tone (irrelevant condition). While highly skilled performers were most effective under the environmental/EF and irrelevant conditions, low-skilled participants performed best under the opposite (i.e., skill-related) conditions. The authors suggested that perhaps, optimal instructions for novice performers are those which promote a focus on the details of task execution, whereas task-related foci would hinder experts' execution of already proceduralized skills. The results of a similar study on golfing performance (Perkins-Ceccato, et al., 2003) offer further support for this notion. High- and low-skilled golfers in this study were asked to focus on the form of their swing and the amount of force used on each attempt or on hitting the ball as close to the target as possible. The former instruction constituted a skill-focus, directing attention toward the execution of the swing, whereas the latter represents an external, outcome-based focus. As predicted by Castaneda and Gray, novice golfers performed more consistently when initially given the skill-focus instruction, whereas highly skilled golfers demonstrated the opposite result. Taken together, these studies suggest that novice and expert responses to focus instructions may vary based on the extent to which the instructions direct attention toward or away from skill execution.

The findings discussed above differ from those of traditional research comparing IF and EF instructions. These "traditional" studies typically demonstrate that novices perform more effectively under EF versus IF instructions, even if the internal instruction promotes a skill-based focus. Expert responses in this body of research, however, have varied substantially (e.g., Porter & Sims, 2013; Stoate & Wulf, 2011; Wulf, 2008).

Experts' responses to attentional focus instructions. Studies examining the effects of focus instructions on expert performance have produced varied findings. Distinct response patterns among experts may have emerged partially due to subtle differences in expertise levels across studies. For example, a series of experiments showed that highly skilled soccer athletes benefited from EF instructions in a sprinting task, whereas athletes who specialized in sprinting (i.e., collegiate and professional track and field athletes) did not benefit from either IF or EF instructions compared to baseline (Winkelman, et al., 2017). Studies on jump roping tasks have yielded similar findings. Porter et al. (2016) found that skilled participants (i.e., athletes who had used jump rope as a conditioning exercise) benefited from instructions to focus on rotating the rope handles. However, when internationally competitive jump rope athletes were given a very similar focus instruction, their performance was significantly degraded compared to baseline (Couvillion & Fairbrother, 2018).

As shown in Couvillion and Fairbrother's (2018) and Winkelman et al.'s (2017) studies, performers who have reached extremely high levels of expertise tend to excel under conditions in which they are allowed to freely direct their attention. Experts' effectiveness under no-focus control conditions may indicate that these performers have developed individualized focus cues which are optimized for their own performance needs. This proposition aligns with the results of Maurer and Munzert's (2013) investigations, which demonstrated that skilled basketball players performed more effectively when they focused on familiar versus unfamiliar stimuli, regardless of the internal or external nature of these stimuli. As it seems logical that experts have developed highly effective focus cues, exploring the nature of these cues may be a useful strategy for informing future research and providing guidance to practitioners.

Expert reports of attentional strategies. When expert performers are asked to report their preferred methods of attentional focus, they consistently describe a range of strategies. These strategies commonly include focusing on internal stimuli (e.g., Diekfuss & Raisbeck, 2016). Other reported strategies fit the traditional definition external foci, while still others constitute alternate types of foci which do not truly fit into internal or external categories. It is also apparent that experts may rapidly shift their focus, attending to a variety of informational sources and thoughts during a single performance. For example, when expert horseshoe pitchers were asked to recount their thoughts during pitching, 96% of them reported a primary focus on external targets, but their thoughts were directed to a wide variety of factors, including various aspects of technique, visual targets, emotional and attentional control, and overall success (Fairbrother et al., 2016). These results indicate that experts may frequently shift their attention and thought patterns through the course of skilled performance. It also seems plausible that the athletes in this study perhaps used their reported external focal point (usually a point on the stake) as a sort of attentional anchor, even though their thoughts seemed to fluctuate.

Complementary findings were reported in another study investigating the focusing patterns of elite figure skaters (Bernier et al., 2016). Across their four-minute competition programs, the skaters attended to features such as the timing of movements, body positioning, energy conservation, fatigue, and artistic aspects of performance. Results of this study also revealed that several skaters rapidly shifted their attention across preparation, execution, and evaluation phases of movements. During the preparation phase (i.e., directly prior to initiating a skill), they often focused on technical movement components. These technical components included IF cues such as quickly drawing an arm backward as well as cues which could be considered neutral (i.e., neither IF nor EF) such as “picking up speed.” During the actual execution of skills, some skaters maintained a focus on body positioning while others described switching to an “automatic mode,” and then “waking up” as they landed the skill. Interestingly, some skaters indicated that their decision to either shift to an automatic mode or maintain a skill focus during execution was based on whether or not they had obtained the correct body positioning during the preparation phase. Thus, attentional decisions seemed to be governed by online kinesthetic evaluations rather than on a pre-determined focus regimen. Research on skilled golfers has provided support for the use of this type of situational decision-making, as reports have shown that golfers may shift their pre-performance attentional focus patterns based on performance of the previous putt. (Bernier et al., 2011).

Expert performers have also described using abstract and metaphoric focusing strategies. For example, dancers in Guss-West and Wulf’s (2016) study focused on “feeling like a swan,” or “stretching like a star in all directions” as they performed a balancing skill. The use of such abstract foci is consistent with other research showing that high level performers often conceptualize performance through idiosyncratic metaphors that carry personal meaning (Hanin & Stambulova, 2002). It has been suggested that these metaphoric focus cues elicit attentional states which are functionally analogous to those of external foci (Guss-West & Wulf). However, without further research, it is unclear how experts actually perceive their own metaphors and abstract cues. For example, the dancer who reported focusing on “feeling like a swan” may have perceived the metaphor as a holistic representation of the movement goal – gracefulness and balance (i.e., functionally similar to a traditional EF). Alternatively, the dancer may have used the metaphor to elicit a more detailed focus, perhaps on the extension of the neck to mirror the long neck of a swan (i.e., functionally similar to a traditional IF). As such, future research will be necessary to understand the underlying meanings and functional effects of experts' abstract foci.

Furthermore, research is needed to uncover the processes by which experts develop individualized, and presumably highly effective, focus cues. Although little is known about the attentional development of high-level performers during the learning process, experts' interview responses from prior research may provide some insight. For example, elite golfers in Bernier et al.'s (2011) study reported using distinct focus strategies at certain times during training and competition. They specifically reported a much greater use of process foci (often internally directed) during training and outcome foci during competition. This distinction seems to indicate that golfers perceived process foci to be useful for skill refinement, but only in situations when optimal performance was not immediately necessary (i.e., in training).

Interview responses from an Olympic level javelin thrower may provide additional insight into the appropriate use of process foci (MacPherson et al., 2008). For performance during competition, the thrower emphasized the importance of focusing simply on rhythm. No reference to process or skill-based foci was made with regard to competition focus. During training, however, a specific use of process-foci was mentioned. Namely, the athlete described working on a technical skill component for a few throws, and then trying to "slot it into the total movement." This strategy represents the integration of a specific skill-based focus into the athletes' holistic, and likely rhythmically grounded, representation of the entire movement. Such a process of shifting between part- and whole-skill foci may also be an effective way for other performers to prompt technical refinements and subsequently facilitate improved performance during competition. Empirical tests of this strategy will be necessary to determine its generalized effects.

Based on expert reports representing a variety of disciplines, it seems clear that optimal attentional approaches become increasingly complex, individualized, and less compliant with traditionally accepted recommendations as performers progress to higher levels of expertise. It is also apparent that experts have discovered foci which are effective for eliciting high-level performance and continual, long-term improvements. As such, gaining insight into the functional nature and the development of these focusing strategies will likely help researchers and practitioners to develop truly optimal attentional protocols.

Summary and Conclusion

Within the body of empirical research examining attentional focus, the effects of focus instructions on motor performance have frequently demonstrated external focus benefits. Effects on motor learning, however, have been less consistent. While the majority of experimental research in this realm still favors the use of EF instructions, several studies have revealed no learning differences between participants who practice under internal versus external focus conditions. Several factors may underly these contradictory findings, including the functional consistency between focus instructions and task objectives, perceptions of autonomy support, the length of acquisition phases, and the level of participants' expertise. Based on the apparent influence of these factors on experimental results and the diversity of focusing strategies reported by expert performers, it seems clear that optimal methods for directing attentional focus are much more complex than research has accounted for thus far. Future research should further explore the nature and development of experts' focusing strategies across the learning process, with an aim toward developing instructional protocols which mirror experts' approaches. Testing the effects of these protocols against traditional all-external approaches may provide more meaningful insight into effective methods of directing focus in real-world situations.

CHAPTER 3

Method

The project consisted of two studies. Study 1 was an exploratory analysis of elite jump rope athletes' self-reported attentional focus strategies during the process of learning new jump rope skills. Data from Study 1 was used to develop an instructional model for directing attention in a manner aligned with experts' reported approaches. This model was experimentally tested in Study 2 in comparison to traditional attentional focus approaches to identify potentially differing effects on motor performance and learning.

Study 1

Participants

Participants were expert jump rope athletes who were highly skilled in Single Rope Freestyle. Inclusion criteria stipulated that participants were between 14 and 39 years of age at the time of data collection. This age range resulted because jump rope athletes typically reach their peak competitive status between the ages of 14 and 39, and thus represents a reflection of the expert population. Participants were also currently active in single rope training. Participants had also earned one of the top three places at the Grand World Championship in a Single Rope Freestyle event during at least one of the past three years or were working as a professional jump rope performer at the time of data collection. In order to qualify for the Grand World Championship, athletes must rank in the top 6 to top 10 places, depending on the event, across all age divisions during the preliminary world competition. Thus, participants were among the top international jump rope athletes. Prior to taking part in the study, participants were asked to provide voluntary informed consent. For all minor participants, parental informed consent was obtained before participants were asked to fill out an assent form. Participants' names and likenesses were kept confidential; each participant was assigned a numeric identification code upon enrolling in the study.

Recruitment. Participants were identified primarily using the competition results from the 2017, 2018, and 2019 World Jump Rope Federation championships. These individuals were contacted via email or social media platforms. A parent or guardian was contacted to obtain permission prior to recruiting minors.

Task and Apparatus

Participants practiced three single rope skills of their choice which were categorized as *Level 3* or higher according to the International Jump Rope Union's (IJRU) 2019 Rule Book. These skills represented three separate elements of Single Rope Freestyle, – multiple unders, power skills, and rope manipulation skills. Multiple unders are skills that require the rope to pass underneath the feet more than one time in a single jump (IJRU, 2019). Power skills are movements requiring a substantial change in body position such as jumping on the hands or moving into a split position. Rope manipulation skills include variations of arm crosses, rope wraps, or rope releases (IJRU, 2019). Figure 1 (Appendix T) provides examples of skills within each of these elements.

Participants were asked to choose one skill within each of these element categories which they had not yet mastered but deemed to be attainable during the current competitive cycle (extending through July 2020). Participants were asked to choose skills that they could successfully complete between 5% and 20% of the time. It is not uncommon for athletes to work toward mastering several skills within each of these categories concurrently. As such, most of the skills involved in this study were those which the athletes were already beginning to learn.

Athletes used their own designated freestyle ropes and completed all practice sessions in settings of their choice (e.g., a gymnasium, outdoor training area).

Procedure

Upon enrollment in the study, participants provided voluntary informed consent (Appendix A). For all minor participants, parental informed consent (Appendix B) was obtained before participants were asked to fill out the assent form (Appendix C). Upon providing consent or assent, participants were given an overview of study procedures (Appendix D). Next, they chose the skills to be practiced throughout the study and completed the initial interview (Appendix E).

Following these introductory procedures, participants completed the first practice session. Additional practice sessions took place over the following two weeks. To gain insight into their preferred learning approaches, participants were asked to practice according to their regular routines. Accordingly, warm up and cool down procedures, practice duration, and the number of trials completed per practice were determined by each participant. Participants were also able to choose whether to practice all three of their chosen skills during each practice session or whether to distribute the skills so that only one or two skills are practiced during each session. It was *suggested* to athletes that they practice each of their chosen skills during four or more practice sessions over the course of the study (i.e., 14 days) and that they practice solo (i.e., without a coach or teammates) to the extent possible. The latter suggestion was designed to limit the potential influence of coaches or peers on the athletes' attention and focus during practice. To minimize the potential for participation to disrupt normal competition preparation, however, the athletes were told that they were not obligated to follow the researcher's suggestions and that they were free to use their own training goals and routines to guide their practice decisions.

Because the goal of the study was to gain insight into experts' foci during *normal* training, it was assumed that slight deviations from the suggested practice structure would not undermine data collection.

The researcher was present during each athlete's first practice session except when travel to the participant was not possible. In such cases, the researcher was virtually present via Zoom video conference. The first practice session was video recorded upon the participant's specific informed consent. During the initial practice observations, immediate verbal recall following each practice repetition was used to gain insight into participants' foci and thoughts (cf. Eccles & Arsal, 2017). Based on Becker et al.'s (2018) study demonstrating participants' ability to differentiate between preparation and execution foci, participants were asked, "What, if anything, did you mentally focus on as you were preparing for that repetition?" and "What, if anything, did you mentally focus on as you were executing that repetition?" Participants were asked to share their preparation and execution foci directly following completion of each trial. Participants were also invited to verbalize any additional thoughts between repetitions (cf. Eccles & Arsal, 2017). All comments were recorded using a voice recorder. Upon completion of the practice session, participants were asked to complete the post-practice survey (Appendix F).

During subsequent practice sessions, the researcher was not physically present with the participant. Participants were told that video-taping of these sessions was suggested but not required. Athletes were asked to use attention logs (Appendix G) to record their preparation and execution foci as well as any relevant notes or thoughts between repetitions. The prompts given on these logs were similar to those used during the first practice session. Participants were also given the option to use a voice recorder or video camera to document their foci in lieu of using the attentional log if they felt that the latter would be inconvenient. Following each session, athletes were asked to complete the post-practice survey (Appendix F) and send it along with the attention log or recording to the researcher via UT Vault Secure Courier. Following the final practice session, participants completed an exit interview to discuss their experiences in the study (Appendix H). All comments were recorded with a voice recorder.

Data Treatment and Analysis

Recordings of exit interviews and verbal reports of foci were transcribed verbatim. Survey responses and attentional log data were entered into Microsoft Excel spreadsheets. Data were organized and separated based on the represented skill category (i.e., multiple unders, power, rope manipulation).

Attentional focus. Initial observation of data revealed that the multiple unders skill category yielded the most clear and consistent foci for developing the attentional focus structure for Study 2. Accordingly, analysis was focused on data within this category. Meaning units (MU's) corresponding to attentional foci were identified. MU's were statements or components of statements representing a singular idea (e.g., "I focused on keeping my chest up). Based on the identified MU's, the total number of preparation and execution foci were tabulated. MU's were then classified by two independent coders (i.e., the lead researcher and a doctoral student with knowledge of attentional focus research) using pre-determined categories based on prior research (e.g., Wulf et al., 1998): *internal*, *external*, and *non-distinguishable*. Internal foci were those which indicated that the participant's attention was directed toward their own body movements. *External* foci were those which indicated that the participant's attention was directed toward the *effects* of their movements, most commonly on the rope's actions. Foci and statements classified as *non-distinguishable* were those for which it was unclear whether the participant's attention was directed toward their own movements or movement effects. The coders' classifications were compared, and all discrepancies were discussed until consensus was reached. Next, the coders worked together to identify common sub-categories based on the content of MU's (see Bernier et al., 2016; Eccles & Arsal, 2017). Coders independently classified MU's according to these sub-categories. Classifications were compared, and all discrepancies were discussed until consensus was reached.

Overall frequency and phase-specific frequency (i.e., during first and second halves of cumulative practice) were then assessed for each content category to provide an overview of attentional approaches. Finally, data was visually displayed in a time-ordered descriptive matrix (Miles & Huberman, 1984) such that content categories were shown as they occurred chronologically. These data representations were used to explore similarities, differences, and patterns in participants' attentional focus approaches with the aim of extracting a generally representative focus model.

Interview and survey responses. Demographics data and skill descriptions were extracted from initial interviews. Exit interview and survey responses that were relevant to the research question (i.e., those related to protocol adherence or to attentional focus during multiple unders skill practice) were analyzed and presented descriptively.

Practice descriptions. Data that was specific to practice regimens (e.g., number of practice sessions, number of repetitions per practice) were extracted from attentional logs and practice videos and organized on a separate Excel spreadsheet. These data were used to determine each participants' total number of practice trials and number of practice sessions completed for their chosen multiple under skill. These measures were then averaged across participants to yield a representative practice model.

Study 2

Participants

Participants were *near-expert* jump rope competitors who were active in single rope training and between 14 and 39 years of age at the time of data collection. Participants had earned one of the top 20 places in their age division at a national or international level competition in a Single Rope Freestyle event during at least one of the past three years (i.e., 2017, 2018, 2019). To eliminate the most successful experts from the sample, athletes who had earned one of the top three places in a Single Rope Freestyle event at the Grand World Championships were excluded from participation. Prior to taking part in experimental procedures, participants were asked to provide voluntary informed consent (Appendix I). For all minor participants, parental informed consent (Appendix J) was obtained before participants were asked to fill out the assent form (Appendix K). Participants were randomly assigned to one of four experimental groups: Internal Focus (IF), External Focus (EF), Expert Modeled (EM), and Expert Modeled – Autonomous (EM-A). Groups were balanced based on participants' baseline scores, age, gender, and years of participation in the sport of jump rope.

Recruitment. Potential participants were identified using the competition results from the 2017, 2018, and 2019 World Jump Rope Federation Championships, USA Jump Rope National Championships, and the 2019 American Jump Rope Federation National Championship. Eligible individuals were contacted via email or social media platforms. A guardian was contacted for permission prior to recruiting minors.

Task and Apparatus

Participants practiced a single rope skill of their choice within the *multiple unders* skill category that was classified as Level 3 or higher according to the International Jump Rope Union's (IJRU) 2019 Rule Book.

Participants were asked to choose a skill which they had not yet mastered but deemed to be achievable during the current competitive cycle (extending through July 2020). Participants were asked to choose a skill that they could successfully complete between 5% and 20% of the time. Although this procedure resulted in differences among chosen skills, it was intended to diminish the potential confound of differing levels of challenge across participants. That is, if a single skill was designated for all participants, some participants would almost certainly have more experience with that skill than others. By allowing participants to self-select skills, challenge and experience level was roughly equated based on the 5-20% success bandwidth. Further, point accumulation used a common scoring approach for all skills and elements, allowing for standardized assessment of participants' responses to focus manipulations, regardless of their chosen skills. In competitive scoring, there is no separation of skills with respect to the manner in which points are accumulated because freestyle routines include many different elements and skills. Thus, it is consistent with real-world practice to compare standardized scoring emerging from different skill types. Athletes used their own designated freestyle ropes and completed all practice and testing sessions in settings of their choice (e.g., a gymnasium, outdoor training area).

Procedure

All participants completed a baseline assessment followed by four practice sessions over the next two weeks. Participants then completed a learning assessment within one week following the two-week practice phase. Upon enrollment in the study, participants provided informed consent or assent and were given an overview of experimental procedures (Appendix L). Next, they selected the skill to be practiced throughout the experiment, completed the initial interview (Appendix M) and baseline assessment, and were assigned to an experimental group.

Baseline. The purpose of the baseline assessment was to obtain an indication of participants' current proficiency in their chosen skill. Participants were told that they should attempt to perform the skill to the best of their ability. The assessment consisted of ten repetitions of the skill with reminders to "perform the skill to the best of your ability" given prior to the first and sixth repetitions. Athletes were asked to warm up according to their regular routines and to rest between repetitions for as long as they deemed necessary for optimal performance. The researcher was virtually present during all baseline assessments via Zoom video conference. Shortly after completing the assessment, participants were given their focus cue(s) for use throughout practice phase of the study.

Practice. Practice sessions took place over the following 14 days. Each of the four practice sessions consisted of 15 repetitions, consistent with the average amount of practice completed by experts in Study 1. Participants were asked to complete the first two practices during the first seven days of the practice phase and the final two practices during the last seven days of the practice phase. Participants were also asked to avoid practicing on two consecutive days to the extent possible. Participants used their preferred warm up, cool down, and inter-trial resting procedures during all practice sessions. Attentional focus instructions were implemented according to each participant's group assignment. To match the traditional instructional approaches used in previous attentional focus research (e.g., Diekfuss et al., 2018; Wulf et al., 2010), participants in the traditional IF and EF groups were assigned one focus cue for use across all practice sessions. Specifically, participants in the IF group were told to "focus on moving your *arms* fast and smoothly throughout the whole skill." These cues were designed based on advice from an expert panel of jump rope athletes and coaches. Participants in the EF group were told to "focus on moving your *rope* fast and smoothly throughout the whole skill." Participants in IF and EF groups were asked to recall this focus cue before each practice repetition and focus intently on their arm motions or rope motions, respectively.

Participants in the EM group were given focus instructions that aligned with the cue structure developed from Study 1 results (Appendix N). In order to align these instructions with the specificity of experts' cues, each participant's focus cues were adapted to match the demands of their chosen skill. See Appendix O for an example of specific focus cues provided to a participant in the EM group. Participants in the EM-A group were given the same focus cues that were given to participants in the EM group. However, EM-A participants were allowed to freely choose when and how to use each cue during practice. See Appendix P for an example of focus cue options provided to a participant in the EM-A group.

At least once during the practice phase, each participant was given a brief attentional reminder via email or text message. Participants were asked to fill out practice logs (Appendix Q) to provide information about their performance on each practice trial. Participants in the EM-A group were also asked to indicate on the practice log which focus cue they chose to use during each trial. Directly following each practice session, participants completed the post-practice survey (Appendix R) to provide information about the practice session and focus cue adherence (see also Couvillion & Fairbrother, 2018). Practice logs, surveys, and video recordings (when applicable) were then sent to the researcher via UT Vault Secure Courier.

Learning assessment. The learning assessment took place within one week following the two-week practice phase. Assessment procedures were identical to those described for the baseline assessment. Directly following the learning assessment, participants completed the exit interview (Appendix S).

Video recording. Baseline and learning assessments were video recorded for scoring purposes upon the participant's provision of specific informed consent. The video camera was positioned to capture the most relevant features of the skill. Participants were asked to record practice sessions and send the video files to the researcher for scoring. In cases where a participant did not consent to video recording, the researcher used live scoring to obtain performance measures during baseline and learning assessments, and practice logs were used to obtain performance measures during each practice trial.

Scoring. All trials from baseline and learning assessments as well as each practice session were assessed to determine whether or not the participant successfully completed the skill.[1] Successful completion was defined as any trial during which the rope successfully completed all revolutions of the skill before cleanly passing underneath both feet upon landing. This scoring technique is consistent with competition guidelines in that skills are awarded points only when the rope successfully passes underneath both feet upon landing.

Data Treatment and Analysis.

Skill completion. The number of successful and unsuccessful trials across practice sessions and in baseline and learning assessments was determined for each group. The relationship between focus group and the number of successful vs. unsuccessful trials in

[1]Not all of the planned scoring procedures were feasible due to a lack of practice session video footage and incomplete or inaccurate notes on practice logs. Specifically, researchers were not able to assess the quality of skill execution as planned.

baseline, practice, and learning assessments was analyzed using separate chi-square tests of independence. Alpha was set to .05 for all statistical comparisons.

Focus cue selections. The specific focus cues selected by participants in the EM-A group were tabulated and presented descriptively.

Post-practice survey responses. Focus cue adherence ratings were tabulated and presented descriptively. Responses to open-ended questions relate to attentional focus (i.e., "What, if anything, was difficult about focusing on the cues?" and "What else, if anything, do you remember focusing on during practice?") were coded, tabulated, and presented descriptively. Initial analysis revealed that responses to the remaining survey items did not provide substantial insight related to the research questions. Therefore, these responses were not included in analysis.

Interview responses. Demographics information was extracted from initial interview recordings and used in conjunction with baseline scores to determine group assignment. Responses related to skill descriptions and estimates of completion rate were used to ensure that participants' chosen skills fit within the study guidelines.

Exit interviews were transcribed verbatim. Responses to all questions related to attentional focus were coded and presented descriptively. Initial analysis revealed that responses to other questions did not provide additional insight related to the research questions. Therefore, these responses were not included in analysis.

CHAPTER 4

Results

Study 1

Participants

Participants were seven (four males, three females, M_{age} = 20.7 years) expert jump rope athletes. Participants reported having been involved with the sport of jump rope between nine and 19 years (M = 13.4). Six participants had earned one of the top three places in at least one Single Rope Freestyle Event at the Grand World Championships during the past three years. The remaining participant worked as a professional jump rope performer.

Practice Descriptions

Participants completed two to seven practice sessions (M = 3.7 sessions) across the study. During each practice session, participants completed between four and 59 repetitions of their chosen multiple under skill (M = 14.8 repetitions).

Attentional Focus

Participants reported at least one attentional focus cue on 71% of practice trials. Preparation foci were reported during 56.2% of practice trials. Execution foci were reported during 25.6% of practice trials. Three of the seven participants reported execution foci on 3% or less of their practice trials. Due to the low frequency of execution foci, preparation foci and execution foci were combined for analysis.

Directional classification of focus cues. A total of 420 meaning units (i.e., distinct foci) were identified. Of these foci, 206 (49%) were classified as internal (IF), 60 (14.3%) were classified as external (EF), and 154 (36.7%) were classified as non-distinguishable (N). IF cues were statements indicating that attention was directed toward the movements of the body.

Examples include, “thinking about…swinging my arms straight into the CL,” and “focused on crossing my arms really big.” EF cues were statements indicating that attention was directed toward the effects of one’s movements, most frequently, on the movements of the rope. Examples include, “I need to make sure I let go of my handle late so it stays close to my body,” and “The rope needs to be spinning faster.” Statements that did not clearly refer to body movements or external outcomes were classified as N cues. For example, “Do a quick second side swing into release” was categorized as N because it was not clear whether the participant’s attention was directed to quick arm movements or quick rope motions. Similarly, “get as much height as I can,” was classified as N because it was unclear whether the participant’s attention was directed internally or externally.

Content classification of focus cues. Table 1 (Appendix U) contains examples of cues within each content category and the number of times each type of cue was used across the first and second halves of practice. The majority (87.6%) of cues were specific to the process of skill execution. *Process* foci were subdivided into *object manipulation* cues and *foundational* cues. *Object manipulation* cues involved a focus on rope control or on the movement of the upper limbs, which directly affected the rope. These cues were further classified as either *movement quality* or *timing* cues. *Movement quality* cues were statements indicating that attention was directed toward the position or specific motion of the rope or the upper limbs. *Timing* cues were statements indicating that attention was directed toward rope speed, upper limb speed, or the relative timing of skill components. *Foundational cues* constituted the second category of *process* foci and involved a focus on structural elements of skill execution. These cues were further classified as either *body position* or *height* cues. *Body position* cues were statements indicating that attention was directed toward the position of the lower limbs or trunk. *Height* cues were statements indicating that attention was directed toward jump height. The remaining focus cues were categorized as *outcome* cues (4.3%) or *general performance* cues (8.1%). *Outcome* cues were statements indicating that attention was directed toward achieving general success. *General performance* cues included statements indicating that attention was directed toward mental processes such as motivation, effort, or commitment to the skill.

Patterns of attentional focus. Participants often reported using cues of the same category on consecutive trials. Specifically, cue types were repeated on 38% of trials. No other patterns were observed with regard to the order in which experts selected certain types of foci. Most participants used responsive selection methods in that their specific foci were determined based on their performance on previous repetitions, yielding highly unique patterns of foci across participants. There were no indications that participants selected focus targets in a pre-determined or planned manner.

Self-evaluations of performance and reported attentional focus strategies. Participants reported specific evaluations of their performance after 49.5% of practice trials. Evaluations were provided spontaneously (i.e., not requested by the researcher) and were often provided in lieu of execution foci. The majority of evaluations (115) were based at least partially on the participant's subjective evaluation of the position or movements of the rope or body during execution. For example, participants reported evaluations such as "My hand was still too far away," and "My rope is a little wonky going into the TS." Sixty-one evaluations were based at least partially on objective evaluations of the rope's placement in relation to the body, usually upon landing the repetition. Examples of these evaluations include, "I [(i.e., the rope)] keep hitting my right leg and not my left," and "It landed above my shoes, which means that the rope is obviously not turning fast enough." Forty-one evaluations were based on the participant's general perception of the repetition (e.g., “That one felt better.”). Participants often used their evaluations to prescribe an appropriate focus or strategy for subsequent repetition(s). For example, one participant stated, “Okay, I'm happy because the rope isn't flying out as much as it was before, but I'm also thinking now of another way just to get the handle a little bit closer. I'm actually going to do less with the arm that's swinging across because maybe…if I do less here [when arm comes across], less will happen on that end [of the rope].” Another participant explained, “That one whipped me on my right side, so maybe I need to get my left arm there quicker.” Other participants provided more simple evaluations and subsequent focus prescriptions such as reporting that their shoulders twisted during one repetition and planning to focus on keeping the body straight for the next repetition.

Development of Attentional Focus Cue Structure

A representative attentional focus structure (Appendix N) was developed based on general practice descriptions and on the frequencies with which experts used each classification of focus cue during first and second halves of practice. To align with the mean number of practices (M = 3.7) and repetitions per practice (M = 14.8) completed by participants, the cue structure included four practices with 15 repetitions per practice.

General categories of focus cues within cue structure. Outcome cues and general performance cues were excluded from the representative structure due to their vague nature and infrequent use during practice sessions. Process focus cues, including both object manipulation and foundational cues, were included in the structure and organized based on their occurrence during practice. To account for variations in the number of cues reported across participants, the proportion of process cues representing object manipulation and foundational cue categories were calculated for each participants’ first and second halves of cumulative practice. In the first half of cumulative practice, object manipulation cues and foundational cues accounted for an average of 65% and 35% of skill-specific cues, respectively. Based on these values, each of the first two practice sessions in the cue structure included 10 object manipulation cues and five foundational cues (i.e., 67% and 33% of total cues, respectively). In the second half of cumulative practice, object manipulation cues and foundational cues accounted for an average of 76% and 24% of skill-specific cues, respectively. Based on these values, each of the final two practice sessions in the cue structure included 11 object manipulation cues and four foundational cues (i.e., 73% and 27% of total cues, respectively).

Subcategories of focus cues within cue structure. Across both halves of cumulative practice, proportions of speed and timing cues and movement quality cues were relatively equal to each other. Proportions of body position cues and height cues were also relatively equal to each other. Accordingly, the number of speed and timing cues and movement quality cues in each practice session of the cue structure were equivalent to the extent possible, and the number of body position and height cues were equivalent to the extent possible.

Order of attentional focus cues. The same focus cue category was assigned on consecutive repetitions approximately 33% of the time to align with experts' cue repetition patterns. The content of cues within each category was modeled after common cues reported by experts. Specific cue content was also adapted to fit each participant's chosen skill.

Exit Interview Responses

Overall experience. When asked to describe their general experience in the study, three participants commented on the helpfulness of the protocol for gaining understanding of their chosen skill or for enhancing the effectiveness of practice. Two participants did not clearly indicate whether the protocol was helpful or unhelpful, and one participant said definitively that the protocol was not helpful. Another participant expressed that the "reflective kind of practice" used in the study likely would not be helpful for learning brand new skills but would be helpful for refining well-learned skills. Almost every participant (i.e., six of seven) expressed that the style of practice in the study was different than their normal methods. Specifically, three participants said the protocol led to a slower pace of practice than normal, and four participants expressed that their typical practice style involved less conscious thought or less awareness of their mental focus. When describing his usual practice sessions, one participant explained, "I usually don't stop between [repetitions]; I'll do it…I do it again, I do it again, until I'm so out of breath I can't physically do it again. Then I stop and think about it…whereas this time I had to stop and take breaks, and that kind of slowed down how I kind of chart my way through the trick." Other participants expressed a similar tendency to complete back-to-back repetitions in order to maintain the "feeling" of doing the skill, particularly after successful repetitions. Another participant expressed that the study protocol "makes me more aware of what I'm doing wrong and how to fix it instead of just kind of making my body figure out how to make it work."

Focus direction. Participants discussed their attentional focus primarily with regard to their current focus when performing their chosen multiple under skill and with regard to changes in focus across the study. All participants reported focusing internally on elements such as arm position, arm speed, body position, and wrist motion. All except one of these participants directly connected the stated internal focus with an external goal (i.e., a desired effect of the rope). For example, one participant reported focusing on reaching his arm as far as possible underneath his leg so that the rope would stay close to his body. Another participant reported focusing on arm motions that affect the rope angle. In addition to internal foci, three participants also reported focusing externally on the placement of the rope, the angle of the rope, and on pulling the rope under to complete the last revolution of the skill. A fourth participant stated that he typically thinks about the rope only when performing very simple multiple under skills. During more complex or difficult multiple under skills, however, he reported a tendency to focus on body position. Finally, six participants discussed foci that did not cleanly represent internal or external focus categories included jumping high, going fast, and ensuring correct timing of each skill component. Overall, the foci discussed during the interviews aligned with the focus cues that participants reported during practice sessions.

Reduced focus during skill execution. While the majority of participants expressed some perceived benefit associated with increased conscious awareness during practice, six participants also emphasized the importance of avoiding excessive conscious thought, particularly during skill execution. One participant explained "when I was too conscious on my thoughts during a skill, it kind of overloaded me at the same time… and I had to be like, 'okay, let's just go back to basics and try not to think too much.'" This same participant said he noticed a performance improvement when he began "thinking of the skill as a whole." Participants specifically addressed the need to minimize conscious thought during execution of a skill, stating that "it's too fast" for detailed thought. One participant described telling herself during the preparation phase, "you have to get higher...or turn faster" and then not really thinking about anything during execution. Another participant described walking through the skill before execution (i.e., performing the revolutions of the multiple under skill separately) "to get my body used to going in straight and fixing that, because a lot of times when I'm doing the trick my brain is just saying, 'OK go really fast, go really fast.'"

Developing automaticity. Several participants discussed the process of “walking through skills” in relation to reducing attentional demand for subsequent repetitions. One participant said that for new multiple under skills, "you have to jump through it in single bounces and slowly build your way up so that once you fully go for it your muscles will kind of just know where to go." Another participant described a similar process, saying, I'll step through the motions of the multiple skills first before I do it. I do that over and over again, like get it ten times...now let me try it. I think a lot of it is about teaching your body what positions to be in…you have to like carve in the neural pathways so your body is going to hit these positions that it needs to at any point in time." Developing this capability to move automatically was associated with the ability to focus more effectively. One participant noted, "The more skills within a skill that you have automatic, the easier the skill is going to be to complete because you can focus more on the things that you're struggling with." This participant also recalled that he was "focusing a lot on just the motions themselves" at the beginning of the study, but said "once I could perfect each motion, and I could focus more on just jumping high enough for the multiple, it became a lot easier."

Accuracy of reported foci. As a manipulation check, each participant was asked whether they felt they were able to accurately report the content of their attentional focus during the study. All seven participants stated that they felt they were able to provide accurate reports of their thoughts and foci.

Brief Summary of Important Findings

The most important outcome of Study 1 was the development of the expert-modeled attentional focus cue structure to be tested in Study 2. Study 1 findings highlighted the varied nature of experts' attentional focus strategies during the learning process. In line with prior research, participants reported focusing on a wide range of cues that varied in terms of their direction and content. External focus cues represented a relatively small portion of the experts' foci, perhaps indicating that internal focus cues can be effectively used during the learning process. Moreover, participants commonly paired internal or non-distinguishable focus cues with goals that were external in nature. This observation may warrant future research to determine the efficacy of such a combined approach for learning in other populations. Additional discussion of Study 1 findings is provided in Chapter 5.

Study 2

Participants

Fifty-six experienced jump rope athletes volunteered to participate in the study. Four participants were excluded from analysis because they did not adhere to or did not finish the experimental protocol. Two were excluded because their skill levels did not align with those represented by the rest of the sample. Two were excluded due to low focus cue adherence ratings on post-practice surveys (i.e., mean adherence rating below 40%). The final sample included 48 participants (41 females, 7 males, M_{age} = 16.9 years, $M_{experience}$ = 9.6 years).

Performance and Learning

Baseline. The total number of successful trials completed at baseline for each group is presented in the left panel of Figure 2 (Appendix T). Participants in all groups performed similarly at baseline, successfully completing approximately 25% of trials. Results of a chi-square test of independence revealed no significant relationship between group assignment and success at baseline, X^2 (3, N = 48) = 3.604 (p > .05).

Practice. The total number of successful trials completed during each practice session for each group is presented in Figure 2. Across practice, the total number of successful repetitions was lowest for the IF group and similar for the EF, EM, and EM-A groups. Results of the chi-square test of independence indicated no significant relationship between group assignment success across practice, X^2 (3, N = 48) = 1.47 ($p > .05$). Follow-up chi-square tests conducted for each practice session also indicated no significant relationship between group assignment and success during any practice session (all p's > .05).

Learning assessment. The total number of successful trials completed during the learning assessment for each group is presented in the right panel of Figure 2. Participants in the IF and EM-A groups performed similarly to each other and completed fewer successful repetitions compared to the EF and EM groups. Results of a chi-square test of independence revealed significant relationship between group assignment and success during the post-assessment, X^2 (3, N = 48) = 24.15 ($p < .001$). The IF group and EM-A groups performed fewer successful repetitions than expected (X^2 contributions = 5.62 and 2.02, respectively), and the EF and EM groups performed more successful repetitions than expected (X^2 contributions = 1.23 and 7.22, respectively).

EM-A Group's Selected Focus Cues

The number of times each participant in the EM-A group selected each type of attentional focus cue during each practice session is presented in Table 2 (Appendix U). Across all sessions, participants chose to focus on speed and timing cues most frequently, followed by arm position and body position cues. Cues related to jumping height were cited least frequently. Ten of the 12 participants reported focusing on a single cue during each repetition. The other two participants reported focusing on two cues during each repetition for about 50% of practice trials.

Survey Responses

Adherence to given focus cue(s). Focus cue adherence ratings for each group during each practice session are reported in Table 3 (Appendix U). During each practice, between 77% and 83.3% of participants indicated that they were able to focus on their given focus cue(s) more than 60% of the time. Participants in the IF and EM groups selected the highest (81-100%) adherence rating most frequently. Participants in the EF and EM-A groups selected the highest and second highest (61-80%) adherence ratings most frequently. Overall, the number of times participants selected the highest focus rating increased across practice sessions, while the number of times participants selected the second highest focus rating decreased across practice sessions. The number of times participants selected the three lowest focus ratings (i.e., 0-20%, 21-40%, and 41-60%) were low and remained relatively consistent across practices.

Difficulties with adhering to given focus cue(s). In response to the survey item "What, if anything, was difficult about focusing on your given cue(s)?," participants primarily reported challenges related to performance impairments, attentional diversion toward other aspects of skill execution, and miscellaneous distractions. Performance impairments associated with their given cues were cited most often by participants in the IF group and least often by participants in the EF group. One participant said, "Occasionally when thinking about the cues, I would rush my arm movements, which would cause a miss." Another participant indicated, "Sometimes when I focus really hard, it causes me to miss." Difficulties caused by attentional diversion toward other aspects of skill execution were cited most often by participants in the EF and EM groups. One participant in the EF group stated that due to fatigue during practice, she focused on jumping high rather than on her given focus cue. A participant in the EM group noted that it was difficult to focus only on one cue for each repetition. This participant "occasionally found [herself] thinking about 2 or 3 different cues from the previous reps" as well as the cue designated for the current repetition. Other participants in the EM group avoided the temptation to divert focus to other cues. For example, one participant explained that "sometimes I didn't feel like [the designated cues] were what I needed to fix, so I wanted to do something different, but I kept following the cues." Participants also listed several miscellaneous distractions that influenced their ability to focus on the cues. Such distractions were cited least often by participants in the EM group. For participants in each of the other groups, miscellaneous distractions were cited more often than any other type of challenge. Examples of distractions listed include fatigue, environmental distractions (e.g., heat or cold), equipment malfunctions, emotional distractions (e.g., frustration), and simply forgetting the focus cue. There were also many instances where participants indicated no difficulties with focusing on their given cue(s). Across groups, participants indicated no difficulties more often in each practice compared to the previous practice, suggesting that participants' ability to focus increased with practice.

Other focus targets. When asked to indicate what they focused on besides their assigned cue(s), participants cited both object manipulation foci and foundational foci. Object manipulation foci were cues related to the control of the rope or the upper limbs. Foundational foci were cues related to the structural elements of skill execution. Of the object manipulation foci, speed and timing cues were the most frequently cited by participants in all groups. Some speed and timing cues were related to specific skill components such as "pulling arms out of the AS quick enough," while other cues were related to general speed such as "speeding the whole trick up." Participants in all groups also cited movement quality foci such as "crossing big" and "making [the] side swing into the EB low to help keep the rope more vertical." Of the foundational foci, jumping height cues were mostly frequently cited across all groups. Participants also occasionally listed body position cues, mostly related to keeping the chest up (i.e., maintaining upright posture) and tucking the legs.

Interview Responses

Perceived helpfulness of given focus cue(s). Table 4 (Appendix U) contains the number of participants in each group who selected each response option for focus cue helpfulness. Ninety-six percent of participants said that the cues were either “very helpful” or “somewhat helpful.” The highest rating was selected slightly more often by participants in the EM and EM-A groups compared to the IF and EF groups. The second highest rating was slightly more common for participants in the IF and EF groups compared to the EM and EM-A groups. Only two participants selected a rating lower than “somewhat helpful.”

Participants cited three primary reasons why their given focus cue(s) were helpful for learning. Most commonly, participants said that their cues helped them direct their attention more deliberately or more effectively than usual. For example, one participant said, “originally I wouldn’t have been focused on certain parts of the skill, and I would have just been trying it to see if I would somewhat get it, but now I know exactly where to focus.” This reason was cited with similar frequency by participants in all groups. Participants in the IF and EF groups also perceived their focus cues to be helpful because they were relevant to the crucial elements of skill execution. The final reason that was cited for focus cue helpfulness was that the cues helped participants to diagnose specific problems in their execution or helped them to identify specific foci that helped them improve their performance. This reason was cited only by participants in the EM and EM-A groups (n=2 and n=6, respectively). One participant in the EM-A group explained that the focus cues helped her “understand the reason behind why [she] was missing and what parts of the trick need to be emphasized or de-emphasized in order to get it.” Another participant in the EM group said that the cues helped him understand what to focus on in order to “get [the skill] more consistently in the future.”

Occasionally, participants who did not select the highest rating for perceived helpfulness explained why they felt the cues were less than "very helpful." Participants in the IF and EF groups frequently reported that although the cues were helpful, they did not address all the necessary components of skill execution. Several participants in the EM and EM-A groups explained that some cues in their instructional set were helpful, while others were not helpful.

Focus on arms vs. rope. Participants in the IF and EF groups were asked a follow-up question during the final interview to determine the extent to which their given focus cues induced an internal focus on their arms versus an external focus on the rope. The majority of participants in the IF group reported focusing primarily on their arms (n=6) or on both their arms and the rope (n=4). For example, one participant described focusing on "my arms along with the rope because I felt they went together in a way. So I would cross bigger to help the rope move better." One IF participant reported focusing primarily on the rope, and one participant did not definitively answer the question. The majority of participants in the EF group reported focusing on both their arms and the rope (n=7). Four EF group participants reported focusing primarily on their arms. One of these four participants, for example, reported, "I think about my hands, and then I don't think about the rope, but then it still [moves]." One EF group member reported focusing primarily on the rope, explaining that the instruction to move the rope faster caused her to think about her "handle...like where it meets the rope."

Perceived changes in attentional focus. Forty-two participants said that they felt their attentional focus related to their chosen skill had changed across the study. One participant did not feel that their focus had changed, and five participants did not provide a definitive answer. The most frequently cited change for participants in the IF and EF groups was an increased focus on their given cues. For participants in the EM-A group, the most frequently cited change was an increased understanding of their chosen skill and of their own mistakes. For example, one participant said, "I can now understand more easily what I did wrong because when I did each rep, I always had to kind of figure out what I did wrong so I could use one of the cues you gave me.” Participants in the EM group reported a similar increase in skill understanding and ability to diagnose mistakes. Participants in this group also commonly reported transitioning from a non-specific focus or a lack of intentionality to a more deliberate focus across the study. One participant explained that before the study, she "mainly just focused on trying [the skill]," and that she "wasn't really focused on specific parts of the skill." At the end of the study, however, this participant focused specifically on arm position, explaining that this is "the biggest thing that I have to focus on personally for this skill."

Attentional focus during the learning assessment. Participants reported adopting a variety of focus strategies during the learning assessment. Most participants (n = 36) focused on multiple aspects of skill execution, while the remaining 12 participants reported a singular focus. Half (n=6) of those who reported a singular focus described a whole-skill or outcome-based focus. For example, one participant said that he focused on doing his “best to complete the skill that is in [his] head.” Another participant said that she thought through the skill prior to executing each repetition and then tried to clear her head during execution. The other six participants who reported a singular focus said that they focused on the cue they were given during practice.

Participants who reported attending to multiple aspects of skill execution cited various combinations of object manipulation foci and foundational foci. Object manipulation foci, including movement quality and speed and timing cues, were the most frequently cited and were cited fairly equally across groups. Of the foundational foci, height cues were cited most frequently. Participants in the EM and EM-A groups reported focusing on height more frequently than participants in the IF and EF groups. Body position cues were the least frequently cited foci across participants in all groups.

CHAPTER 5

Discussion

Study 1

Previous research has presented an overly simplified view of attentional focus and its effects on motor performance and learning. While the majority of findings have demonstrated performance and learning benefits when participants are given external focus (EF) instructions (for a review see Wulf, 2007, 2013), research on expert populations has produced mixed results (e.g., Couvillion & Fairbrother, 2018; Winkelman et al., 2017). Further, experts' natural attentional focus choices have scarcely been studied across the learning process, leaving a gap in understanding regarding their attentional strategy development. The current study sought to fill this gap through a detailed investigation of expert jump rope athletes' attentional focus choices as they practiced new jump rope skills. Results demonstrated that experts' attentional strategies were highly individualized, varied, and responsive to performance outcomes. Along with providing potential explanations for inconsistent results in prior research, the present findings were used to produce an expert-modeled focus cue structure to be tested in other populations.

Descriptions of Reported Focus Strategies

Direction of attentional focus. Among the primary aims of the present study was to gain insight into experts' use of internally and externally directed foci. Overall, results of Study 1 showed that the majority of experts' reported focus cues were classified as internal or non-distinguishable (i.e., not clearly internal or external). External foci were relatively uncommon, representing less than 15% of focus targets.

While this study is among the first to provide insight into the direction of experts' foci during the *learning* process, results can be compared to previous research examining experts' attention during the *performance* of well-learned skills (e.g., Bernier et al., 2011; Fairbrother et al., 2016). Compared to attentional focus reports in these studies, experts in the current experiment reported a remarkably low usage of EF cues. For example, Fairbrother et al. found that 96% of elite horseshoe pitchers focused externally during competition. Bernier et al. (2011) reported that 45% of elite golfers' foci during competition were directed toward the outcome of their shot, representing a subset of external focus targets. The golfers also focused externally on the kinematics of their club, but the precise frequency of these foci is unknown. It is possible that the high frequency of EF cues in these experiments compared to the current study can be explained by differences in task demands as the objective of both horseshoe pitching and golfing is clearly external (i.e., aiming toward an external target), whereas jump rope skills involve a more complex interaction between internal and external objectives. A study by Guss-West and Wulf (2016), however, showed that professional ballet dancers reported focusing externally approximately twice as frequently (i.e., 27% of cues) as the jump rope athletes in the present study, even though ballet movements do not involve any sort of external target or implement. Thus, it seems that differences in internal and external cue frequency between the current study and previous research cannot be fully attributed to task demands. Rather, participants' proficiency with the given task provides a more plausible explanation for these differences, as prior research has examined focusing strategies for the performance of well-learned skills, whereas the current study examined focusing strategies during the learning process.

In addition to diverging from previous results, the current findings call into question OPTIMAL Theory's (Wulf & Lewthwaite, 2016) predictions that an internal focus of attention is detrimental to both performance and learning. While the present study did not provide an empirical test to directly assess these predictions, it is logical to assume that expert jump rope athletes have developed effective strategies for learning new jump rope skills. Thus, the markedly low frequency of external foci and high frequency of internal foci cited by these athletes should prompt researchers to conduct additional tests before generally accepting the predictions of OPTIMAL Theory.

Explanations for Attentional Focus Targets.

Examination of participants' stated rationales for choosing certain foci may provide insight into specific contexts where the use of internal focus strategies may be useful, or at least not detrimental, for learning.

Preparation vs. execution focus. One important factor to consider is the phase during which participants adopted certain focus strategies. The majority of participants' reported foci in the current study were specific to the preparation phase (i.e., the time period directly preceding skill execution). According to Becker et al.'s (2018) findings, adopting an internal focus of attention during this phase may be only marginally detrimental to performance, particularly if the performer shifts to an external focus during execution. Interview responses indicated that such a shift may have naturally occurred for athletes in the current study. Participants frequently noted that attentional capacity limitations during skill execution prompted necessary focus shifts toward directionally neutral cues (e.g., "just go for it" or "go really fast"). Occasionally, participants reported a lack of focus altogether during execution, perhaps allowing for the sort of natural movement control that is typically associated with focusing externally (Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001). It should be noted that these interview responses give insight into participants' retrospective perceptions of their practice experiences. However, because the current data provide relatively few reports of specific execution foci *during practice*, future research is needed to determine whether expert learners reliably shift their focus away from internal targets during skill execution.

Pairing Internal Foci with External Goals. Another factor that likely contributed to participants' use of IF cues was their explicit connection to external goals. Interview responses indicated that many participants focused internally on their arm movements, reasoning that their arms ultimately controlled the rope. For example, one participant indicated that he focused mostly on his wrist motions "because the wrist is what controls the rope." Others made less direct comments pertaining to perceived connections between their own movements and the rope's responses. Participants reported strategically adjusting their arm placement, arm speed, and even their foot placement upon take off in an effort to affect the rope's placement, speed, and angle, respectively. Further, participants' comments throughout practice sessions indicated that their awareness of the relationship between rope and body was active and influential in their real-time attentional choices. Reports of internal foci were often accompanied by intended external outcomes (e.g., getting the rope under the feet, catching the handle). As an example, after noticing that she straightened her legs too early in several repetitions, one participant stated, "I'm going to try to not go so straight and maybe just try to tuck a little more *so the rope won't have to go so low* [in order to pass underneath the feet]." Another participant who chose to practice a multiple under skill with a rope release noted that "the handle is always too far [to catch]; maybe that's because I need to keep my arm close to my body…" Moreover, the majority of performance evaluations were explicitly based on the rope's placement or movement. Based on these responses and statements, it is clear that participants' internal foci were inseparable from external goals and that they were constantly monitoring external stimuli (i.e., the movements and responses of the rope).

It must be considered that experts were able to effectively use internal foci during practice precisely *because* they were anchored in external goals and supported by constant monitoring of external stimuli. This suggestion is consistent with OPTIMAL Theory's line of reasoning. Namely, OPTIMAL Theory suggests that internal focus instructions impair performance and learning by impeding goal-action coupling. However, internal foci that are presented within the context of external outcomes may allow performers to refine body movements without compromising goal-action coupling, thus sustaining performance and learning outcomes. Along this line of reasoning, it may be that some of the detrimental effects of internal focus cues in previous research (e.g., Flores et al., 2015) can be partially attributed to a lack of explicit contextualization or grounding in external outcome goals. The potential usefulness of internal foci that are framed within the context of external goals warrants further research and may have implications for designing effective internal focus instructions in the future.

Attentional Focus Content Classifications

In addition to their directional classification (i.e., internal versus external) experts' focus cues were classified based on their content. While nearly 90% of reported cues were process foci (i.e., directly related to specific components of skill execution), only 4% were outcome foci (i.e., directly related to successful completion of the skill). The incidence of outcome foci in this study is remarkably low compared to prior research (e.g., Fairbrother et al., 2016). Differing contexts and levels of proficiency with respect to the tasks in each study may explain the divergent results. Namely, while most research has examined experts' foci during performance of well-learned skills, the jump rope athletes in the present study were practicing skills which they had not yet mastered. It may be that participants' efforts to understand and refine the key elements of novel skills produced a greater tendency to focus on process cues.

Process foci were further classified as "object manipulation cues" or "foundational cues." Object manipulation cues (i.e., those involving an explicit focus on controlling the rope or upper limbs) were most prevalent, accounting for approximately two thirds of process cues. The remaining process foci were not directly related to rope control and were classified as foundational cues. These cues involved a focus on jump height or movements of the trunk or lower body, elements that form the foundational infrastructure necessary for successful skill execution. This distinction was evident in interview responses. For example, one participant explained, "It became clear that if my body positioning was off, no matter how fast I pull[ed], I probably wouldn't get it under."

A similar distinction between object manipulation cues and foundational cues has been made in previous research (Couvillion & Fairbrother, 2018). This study showed that expert jump rope athletes' performance was impaired when participants were instructed to direct their attention toward control of the rope or their upper limbs. Performance was sustained, however, when the experts were instructed to focus on the sound of their jumping (i.e., away from object manipulation). Based on these findings, it might be assumed that expert jump rope athletes would avoid focusing directly on object manipulation, but the results of the present study showed the opposite pattern. Differences in task demands and participants' task proficiency may explain this discrepancy. In Couvillion and Fairbrother's experiment, participants performed a very simple, continuous jump rope task, whereas participants in the current study practiced highly complex, explosive skills which they had not yet mastered. As such, it may be participants chose to focus on the specific movements of their upper body and the rope in an effort to understand the specific movements and timing required for successful skill execution. Some support for this explanation can be found in Bernier et al.'s (2011) results. These authors found that golfers focused more often on the process of their swing during practice, as they presumably worked to improve their technique, and then shifted toward a greater outcome focus during competition.

Based on these collective findings, it seems reasonable to assume that skilled learners would shift their focus strategies away from specific aspects of skill execution and toward general outcomes as they gain proficiency with a given skill. Results of the current study did not generally show this type of focus shift, perhaps because the brief practice phase did not allow time for skill mastery. However, one participant discussed shifting from a focus on object manipulation toward a focus on foundational skill components. He explained that at first he "was focusing a lot on just the motions themselves," but once he was able to "perfect each motion and…could focus more on just jumping high enough," the skill became much easier. He later explained that "the more skills within a skill that you have automatic, the easier the skill is going to be to complete because you can focus more on the things that you're struggling with." It would be worthwhile to conduct further exploration of experts' attentional strategies across longer acquisition phases to determine how focus may shift across multiple stages of learning.

Attentional variety. The diversity of foci reported by the experts in the current study, including focus cues directed toward skill execution, general success, and mental processes, is consistent with patterns reported in previous research. Bernier and colleagues (2016), for example, found that elite figure skaters adopted similarly diverse attentional strategies, focusing on skill-specific elements such as timing and body positioning as well as more general factors such as fatigue and energy conservation. Elite horseshoe players (Fairbrother et al., 2016) and professional ballet dancers (Guss-West & Wulf, 2016) have also reported a wide variety of thoughts and foci during skilled performance. This attentional variety underscores the complexity of physical and mental demands involved with skilled performance and learning and highlights the importance of developing well-rounded instructional strategies. Based on experts' use of varied focus targets, it seems likely that previous experimental research has offered an incomplete view of effective attentional focus approaches. That is, prior experiments have often tested the effects of singular focus instructions (most commonly, IF vs. EF instructions) that are repeated across practice (e.g., Lohse, 2012; Wulf et al., 1998). The current findings suggest that a different approach altogether, namely an approach using multiple and varied instructions, would allow researchers to more effectively determine optimal instructional protocols.

Focus cue structure. In order to pioneer the testing of more complex and realistic attentional strategies, a focus cue structure was developed based on the attentional strategies reported by the experts in this study. To represent the attentional features that were observed most consistently across all the expert participants, focus cues and their relative frequencies were based on the process foci reported by participants during practice. Within the general structure that was created by cue frequencies, the order of specific foci was essentially randomized to mimic the responsive and constantly changing focus reported by experts.

Cues were designed such that the wording of each instruction matched the common verbiage used by experts. This yielded neutrality in terms of attentional direction. That is, the majority of cues were not designed to explicitly direct attention internally or externally. A few exceptions existed for body position cues which likely directed attention internally by nature (e.g., focus on tucking your legs in). Finally, due to the scarcity of execution foci and participants' comments indicating difficulties with attentional control during skill completion, specific execution foci were not assigned in the cue structure. One cue, designed primarily for use during the preparation phase, was provided for each repetition.

Focus Cue Selection Strategies

Experts' strategies and rationales for selecting certain foci could not be specifically represented in the focus cue structure. However, examining the nature of these strategies is crucial for gaining a well-rounded understanding of experts' focus patterns and informing future research. Consistent with prior research (e.g., Bernier et al., 2011; Cleary & Zimmerman, 2001) participants often selected focus targets based on their performance during the previous repetition. Specifically, after executing a repetition, participants commonly engaged in a process of evaluation, prescription, and preparation before executing the next repetition. This process is consistent with the behaviors of experts and successful learners in previous research (Cleary & Zimmerman, 2001, Laughlin, 2012).

Evaluation and prescription. Evaluations stemmed from two primary sources of information – perceptual/kinesthetic awareness during execution and the rope's placement upon skill completion. Statements such as "[I] felt [my] body twisting left a bit" and "my arms were going too fast" indicate that participants had some level of kinesthetic awareness during execution and were able to recall key details of performance following skill completion. These recollections were often paired with prescriptions for subsequent foci or technique adjustments. As a simple example, after noting that her body twisted left, this participant reported focusing on keeping her body straight for the next repetition. In other cases, evaluations and prescriptions resulted from more objective observations of the rope's placement upon skill completion. One participant noted "it [the rope] hits above my knees, so I'm thinking…my arms are going too slow, because if it's just now hitting then the cross is just too slow, I think." She then explained that she would focus on height to compensate for arm speed.

Occasionally, participants quickly performed two repetitions in a row without pausing to evaluate or prescribe focus. Several participants indicated that they use this strategy primarily after good trials in order to "keep the feeling of it." Statements like "Go right now! Go right now!" indicated a sense of urgency to complete the second repetition quickly. Presumably, participants wanted to recreate the holistic experience of the successful repetition and felt that the perceptual trace of the repetition would fade with time.

These varied patterns of evaluations and focus prescriptions represent the complex perceptual and cognitive nature of participants' learning strategies. They also support the previous suggestion that participants' internal and external focus on their bodies and the rope were functionally inseparable, further emphasizing the need for future research to extend testing beyond dichotomous attentional focus approaches.

Preparation and execution. The preparation phase often included intentional allocation of attentional resources and physical rehearsal of skill components. Participants frequently reported having more than one attentional target during the preparation phase, and as discussed previously, these targets were often tied to prior performance evaluations. However, results suggest that participants had more difficulty allocating attention to multiple stimuli during execution. Participants frequently explained that they had made a mistake in one component of execution (e.g., not jumping high enough) because they were focused only on another component (e.g., increasing speed). Certain incidents also highlighted the fragile nature of intentional focus during execution of explosive skills such as multiple unders. For example, one participant reported, "As I was taking off, I punched myself in the knee; [I] did not think about anything else." Another described a typical process of focusing on several skill components during preparation, and then "my brain just says 'go fast, go fast' when I get in the air." These descriptions are consistent with open-loop control processes that are commonly associated with explosive skills like multiple unders (Schmidt, 1975). Similar attentional patterns have also been documented in other research on experts. Some of the elite figure skaters in Bernier et al.'s (2016) study described going into an "automatic mode" during execution and then "waking up" upon landing. Participants were presumably aware of these attentional limitations during skill execution and attempted to compensate through rehearsing skills during the preparation phase. Participants frequently "walked through" skills (i.e., rehearsed at a reduced speed), explaining that this process helps "your muscles know what to do when you get in the air." The fragile nature of attention during the execution of complex skills emphasizes the importance of optimal focus during the preparation phase, perhaps both mental and physical rehearsal.

Connections to Past Research and Future Implications

The highly diverse, individualized, and responsive focus strategies displayed in the current results not only confirm the findings of previous exploratory research (e.g., Bernier et al., 2011, 2016; Fairbrother et al., 2016), but they may also help to explain the results of previous experimental research on expert performers. That is, experts often do not reap performance advantages under external focus instructions (Couvillion & Fairbrother, 2018; Winkelman et al., 2017; Wulf, 2008) and sometimes demonstrate superior performance under no focus or "control" conditions. If the highly varied and individualized focus patterns which emerged during experts' learning processes in the current study are assumed to persist, yielding similarly individualized focus patterns for well-learned tasks, then imposing a singular focus instruction, regardless of its internal or external direction, would logically disrupt experts' performance.

Further, the current findings suggest that previous studies on attentional focus and motor learning have presented overly simplistic approaches to attentional focus. The attentional strategies of expert learners in the present study do not support the use of dichotomous, internal versus external attentional allocation that has been tested in most experimental research. Not only were the majority of experts' foci ambiguous in terms of direction (e.g., jump higher, go faster), but their comments revealed that they did not readily differentiate between movements of the body and the rope's responses. Rather, experts were acutely aware of the constant interplay between these two entities, and this awareness informed their evaluations and focus strategies. Future research should account for these observed complexities and test attentional protocols that align with the strategies of skilled learners. Study 2 of the current project constituted a first step in this endeavor.

Study 2

Study 2 provided an empirical test of the expert-modeled cue structure developed in Study 1. The effects of this cue structure on performance and learning were tested against traditional IF and EF instructions in a near-expert population. To investigate the potential role of autonomy in reaping benefits from expert-modeled focus strategies, the cue structure was tested in two separate groups, one that was assigned cues in a pre-determined order (EM group), and another that was given autonomy over cue selection (EM-A group). The most important finding from Study 2 was that athletes learned more effectively under expert-modeled focus instructions compared to traditional IF and EF instructions, but only when cues were assigned in a pre-determined order (i.e., when attentional autonomy was *not* given). Taken together, findings highlight the complex nature of optimal attentional strategies and emphasize the need to study attentional focus approaches beyond dichotomous internal and external instructions.

Group Descriptions and Baseline Performance

The athletes in the current study had an average of nearly 10 years of experience in the sport of jump rope, and most had competed at the international level. While their overall experience and accomplishments did not equal those of the experts in Study 1, participants were still considered highly skilled athletes. Therefore, results should be interpreted through the lens of skilled performance and learning. Because participants practiced individually selected skills throughout the study, matching baseline performance was of particular importance to ensure that participants' chosen skills posed similar degrees of initial challenge. The results confirmed this equivalence.

Performance During the Practice Phase

Performance during the practice phase was similar for all groups and during all practice sessions. Thus, it is logical to assume that subsequent group differences during the learning assessment were the result of differential learning effects rather than residual performance effects. The finding that groups performed similarly during practice is consistent with prior research showing that experts' performance did not differ under various attentional focus instructions (e.g., Winkelman et al., 2017, experiment 2; Wulf, 2008). To date, most of the research on experts has investigated performance in well-learned tasks. Thus, the present findings provide an extension of current knowledge, demonstrating similar patterns of expert performance for *novel* skills under various focus instructions.

It is possible that athletes' spontaneous foci during practice contributed to the lack of observed performance differences between groups. Although participants in all groups reported high levels of adherence to their given cues, they also reported focusing on a variety of additional stimuli throughout practice sessions. These additional focus targets mirrored those reported by experts in Study 1, illustrating that the near-experts had acquired advanced understanding of skill acquisition. Further, the content and frequency of spontaneous foci were remarkably consistent for participants across all groups. Thus, the groups' similar allocation of attentional resources to multiple aspects of skill execution may have diluted the immediate effects of attentional focus manipulation, mitigating any performance differences that might have otherwise emerged.

Performance During Learning Assessment

Possible spontaneous foci during practice did not negate subsequent differences observed during the learning assessment. The Chi-Square analysis showed that there was a significant relationship between group assignment and performance. Specifically, results showed a clear learning advantage for the expert modeled (EM) group and a learning detriment for the internal focus (IF) group. Scores of the external focus (EF) group and the expert modeled-autonomous (EM-A) group did not differ substantially from expected values, indicating that there were no reliable learning advantages or disadvantages associated with these instructional approaches.

Because very few previous studies have examined the effects of attentional focus instructions in skilled learners and no studies have tested experts' attentional approaches against traditional instructions, direct comparison of the present findings to existing knowledge is challenging. Research on learning effects in novice populations has revealed mixed results (e.g. Coker, 2019; Diekfuss et al., 2019; Wulf et al., 1998, experiment 2), but general trends support the idea that learning is enhanced through an external focus of attention. Additionally, one of the few studies to examine learning effects in skilled participants showed learning advantages for the EF group and disadvantages for the IF group (Porter et al., 2016). Based on these limited findings, the current results only partially support expectations, showing learning detriments for the IF group but no clear advantages for the EF group compared to other instructional approaches. The current findings also fail to support the predictions of OPTIMAL Theory (Wulf & Lewthwaite, 2016), as neither an external focus of attention nor autonomy supportive practice conditions were shown to enhance learning. Examination of each group's behaviors and subjective experiences across the study will be helpful to gain further understanding of the current findings.

Behaviors and Subjective Experiences of Each Group

Internal and external focus groups. As discussed previously, the internal and external focus groups performed similarly to each other across the practice phase. It is plausible that participants' spontaneous focus on multiple aspects of skill execution may have diluted the effects of the attentional focus manipulations, thus contributing to similarities in performance. In addition to this varied attention allocation, participants' comments during the final interview suggest that the external focus instructions did not always direct participants' focus as intended. That is, 11 of the 12 external focus group members reported that they focused both internally and externally (i.e., on their arms and rope, respectively) or primarily internally during practice, while only one participant reported focusing primarily externally as intended. Participants who focused internally reasoned that their arms controlled the rope, and therefore focusing on their arms allowed them to fulfill the instruction to "focus on moving your rope fast and smoothly." One participant said that when she received her focus cue she thought, "Okay, so when I do [the skill] the movement of my arms is…very smooth." She further explained, "when I read, 'rope,' I kind of just think, 'OK, this is what I need to be doing to make the rope do it." It may be that many of these athletes did not reap the benefits that might be expected from adopting an external focus, thus experiencing performance effects that mimicked the IF group.

Results of the learning assessment, however, suggest that the EF instruction may have provided a sort of protective mechanism against the potentially negative effects of spontaneous internal foci. That is, although many of the EF group members reported adopting an internal or mixed focus during practice, this group did not experience the learning detriments that were observed in the IF group. It is possible that the instruction to focus on the rope may have provided an attentional anchor of sorts for the EF group, ensuring that these participants maintained some level of awareness of the rope's movements, and strengthening the athletes' perceptual connection between their own movements and the rope's responses. Constant reminders to focus on arm movements, however, may have provoked a more exclusive internal focus and hindered participants from learning to effectively control the rope. This view is consistent with the suggestion that focusing internally can disrupt automatic movement control (Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001). While this disruption did not lead to immediate performance detriments, it apparently hindered effective learning for the IF group. Notably, the observed IF learning detriments were mitigated when participants were given multiple attentional targets in the expert modeled cue structure.

Expert-modeled group. Results demonstrated that the EM group produced more successful completions compared to both the IF and EF groups, demonstrating that the expert-modeled instructional approach was superior to traditional attentional focus recommendations. It is unlikely that these benefits can be attributed to the attentional direction (i.e., internal vs. external) that was elicited by the cue structure. In fact, while the cues were not explicitly intended to elicit either internal or external focus, some of the cues (e.g., body position cues) almost certainly drew participants' attention internally. Survey responses also indicated that the majority of EM participants' spontaneous foci were internal or neutral. Thus, the presence of a distinct learning advantage for the EM group suggests that learning detriments associated with focusing internally can be mitigated by multiple-cue instructional approaches.

The varied nature of the expert modeled instructions addressed a common limitation in attentional focus research. Namely, the majority of previous studies showing EF learning benefits have tested singular IF and EF instructions that are repeated across practice (e.g., Fairbrother & Woodard, in preparation; Lohse, 2012; Shea & Wulf, 1999). As demonstrated in Study 1, this approach is not consistent with real-world practices. A few previous studies have addressed this concern by testing the effects of multiple IF and EF instructions (e.g., Agar et al., 2016; Lawrence et al., 2019) or feedback statements (e.g., Perreault & French, 2015), but these experiments have produced mixed results and have not directly compared multiple-cue approaches to single-cue approaches. Thus, the current study is the first to demonstrate that focus cues reported by experts can be used to elicit superior performance on a learning assessment compared to traditional internal or external focus cues.

An inherent weakness of single-cue instructional approaches is that participants are only prompted to focus on one aspect of skill execution. Members of the IF and EF groups in the current study acknowledged this weakness, explaining that their focus cues produced a "lack of focus on other areas of the trick" or left them to "figure out [other skill components] like the speed and your legs." The variety of focus targets in the EM cue structure, however, addressed this limitation by prompting participants to focus on multiple aspects of skill execution during each practice.

While this varied focus supported learning benefits, it may have hindered overall performance during practice. That is, participants frequently reported that while some instructions in the cue structure were helpful for performance, others were detrimental. Because focus cues were repeated in each session, participants were instructed to focus on the cues they perceived to be unhelpful multiple times throughout the practice phase. It seems logical that focusing on these unhelpful cues was at least partially responsible for mitigating immediate performance benefits that may have otherwise emerged for the EM group.

It is also plausible that EM participants' commitment to focusing on a range of helpful and unhelpful instructions contributed to their learning advantages by inducing various levels of challenge and skill-related experiences across practice. While OPTIMAL Theory (Wulf & Lewthwaite, 2016) posits that successful practice experiences yield learning benefits, other researchers have highlighted the importance of experiencing appropriate levels of challenge (Guadagnoli & Lee, 2004) and even errors (e.g., Lee et al., 2015) during practice for optimizing learning. Considering these perspectives, the challenges and performance errors induced by cues that were perceived to be unhelpful combined with the successful experiences associated with preferred cues may have produced the necessary balance between challenge, success, and failure to optimize learning. Further, Schema Theory (Schmidt, 1975) predicts that learning is enhanced through practice conditions that allow participants to experience multiple variations of the motor skill, thus strengthening the learner's cognitive representation of the skill (Schmidt & Lee, 2011). The cues included in the EM instructional set likely promoted such variation in skill experiences, as participants were prompted to emphasize different components of the skill in each repetition. Participants' awareness of this variation was revealed as they recounted instances of over- and under-emphasizing skill components in response to certain focus instructions. Moreover, it seems plausible that the instructional set used by the EM group supported multiple components of learning, inducing appropriate challenge levels (Guadagnoli & Lee) and eliciting varied task experiences (Schmidt). Future research is needed to test these ideas and provide more precise understanding of the mechanisms underlying expert modeled learning effects.

Expert Modeled-Autonomous Group. Contrary to the predictions of OPTIMAL Theory (Wulf & Lewthwaite, 2016), the learning advantages associated with the expert modeled instructional approach were eliminated when participants were given control over their focus cue selections (EM-A group). This finding contradicts the results of previous research showing learning benefits associated with autonomy (i.e., "self-control") over various components of practice such as feedback provision (e.g., Woodard & Fairbrother, *in press*), amount of practice (e.g., Post, Fairbrother, et al., 2011), and instructional assistance (Chiviacowsky, Wulf, Lewthwaite, et al., 2012). Examination of the proposed mechanisms underlying self-controlled learning benefits in past research may explain the divergent findings in the current study.

Some researchers have pointed to enhanced motivation as an explanation for self-controlled learning benefits (e.g., Sanli et al., 2013). Although motivation was not directly measured in the current study, it is unlikely that the autonomy given to the EM-A group would have yielded the motivational benefits described in past research. Enhanced motivation has often been connected to increased perceptions of competence as participants presumably used control over feedback provision to confirm success (Chiviacowsky, Wulf, & Lewthwaite, 2012; Fairbrother et al., 2012) and to obtain information for improving performance (Aiken et al., 2012; Laughlin, 2012). Autonomy over attentional focus in the current study did not provide any additional opportunity for EM-A participants to confirm success or gain helpful information about performance. That is, participants in all groups had access to the same inherent feedback about their performance. There was also no evidence that EM-A participants used their autonomy to select cues that led to immediate performance enhancement. Thus, there is no reason to believe that participants would have experienced enhanced perceptions of competence as a result of their autonomy. According to Chiviacowsky, Wulf, and Lewthwaite's findings, such compromised perceptions of competence may diminish the learning benefits associated with autonomy.

Learning benefits in previous research have also been attributed to direct increases in intrinsic motivation as self-controlled learning manipulations presumably satisfy learners' basic psychological need for autonomy (Deci & Ryan, 2000; Lewthwaite et al., 2015). Support for this view is found in Halperin et al.'s (2017) study showing that competitive kickboxers' performance, and presumably their effort levels (i.e., greater punching velocity), were enhanced when they were allowed to choose the order in which they performed various punches compared to a condition in which the order of punches was pre-determined. Notably, this study along with the majority of other self-controlled learning experiments have been conducted in controlled settings (e.g., a laboratory) wherein participants' general perceptions of autonomy were likely suppressed. It may be that any provision of autonomy in these circumstances produced artificially inflated motivational benefits compared to participants whose autonomy remained suppressed. In the current study, the basic need for autonomy was likely satisfied for all groups as each participant was given control over multiple components of practice such as the time between trials, practice location, practice schedule, physical or mental rehearsal between repetitions, etc. Research in other disciplines such as marketing and economics has revealed that increases in the amount of autonomy experienced may undermine participants' satisfaction (Greifeneder et al.; Scheibehenne et al., 2010). Therefore, it is unlikely that intrinsic motivation would have been enhanced by the provision of autonomy over an additional component of practice (i.e., cue selection). Further, in past studies showing self-controlled learning benefits, participants have typically been asked to choose between two or three simple options (e.g., feedback vs. no feedback). EM-A participants in the current study, however, were asked to choose between ten cues on each of 60 practice repetitions. According to previous research, this large number of choices may have produced a disadvantageous attentional demand and yielded indecisiveness (e.g., Reutskaja & Hogarth, 2009; White & Hoffrage, 2009). Survey responses such as "I was constantly switching between two cues, so it was hard [to know] which one to really focus on" indicate that some participants may have had difficulty managing the additional demands induced by attentional autonomy.

Previous research (e.g., Chiviacowsky & Wulf, 2005; Couvillion et al., 2019) has also demonstrated that enhanced decision making and augmented information processing may be responsible for self-controlled learning benefits. However, attentional disruptions and distractions during practice have been shown to mitigate learning effects, presumably through impaired information processing (e.g., Carter & Ste-Marie, 2017; Fairbrother & Woodard, *in press*). The current study was certainly not void of attentional disruptions. Participants frequently reported experiencing distractions such as environmental concerns, physical fatigue, personal stressors, and equipment malfunctions. It is possible that these distractions impaired the EM-A group's ability to make effective attentional choices during practice, thereby eliminating learning benefits that may have otherwise been expected.

Another possibility to consider is that some participants in the EM-A group were not equipped to accurately evaluate their execution errors and prescribe appropriate cues. This idea is consistent with Laughlin's (2012) finding that the instructional preferences of some participants were misaligned with their needs, leading to incorrect technique development and undermining task proficiency. Observation of practice performance in the current study provides support for this suggestion. Namely, although participants in the EM-A group had the opportunity to tailor their attentional strategies to meet their immediate performance needs, they did not experience any performance advantages compared to other groups whose focus cues were pre-determined (i.e., not tailored to their needs). This lack of performance benefits may be an indication that EM-A participants, as a whole group, were not able to make advantageous attentional decisions.

Further insight can be gained from examining participants' specific cue selections across practice. Although the content and variability of attentional focus for the EM-A group as a whole mimicked that of the EM group, examination of individual participants' choices revealed selections that yielded relatively low attentional variability. Specifically, while the expert modeled cue structure instructed EM group members to focus on all ten cue variations during each practice, only two of the EM-A participants adopted this strategy. The majority of EM-A participants used between one and six of the 10 cues that were available at each practice session. Given the learning benefits associated with experiencing multiple versions of a motor skill (Schmidt, 1975; Schmidt & Lee, 2011), it stands to reason that participants' choices to reduce attentional variability may have mitigated potential learning benefits for the EM-A group.

The finding that autonomy did not yield learning benefits for these athletes emphasizes the essential role of coaching in supporting optimal skill acquisition, even for experienced athletes. That is, although the participants in this experiment had nearly 10 years of experience on average and had competed at very high levels, they learned most effectively when they were given expert modeled attentional instructions in a pre-determined order. It is also important to note that these findings do not negate the potential learning benefits of autonomy. It may be that the extreme nature of autonomy provision in the current study yielded too great an attentional demand and negated the benefits that are normally associated with self-controlled learning.

Future research is needed to investigate how coaches might adjust the nature and level of autonomy given to athletes for optimal learning benefits.

Summary of Important Findings and Practical Application

The current study represents a novel approach for developing an instructional model based on experts' attentional focus strategies and testing its effects on learning in alternate populations. The results of Study t 1 extended previous findings demonstrating the complexity and highly individualized nature of experts' attentional strategies during the learning process. Findings also suggested that experts were able to effectively use internal focus cues, particularly when they are grounded in external goals. Results from Study 2 supported this suggestion in that internal focus instructions were detrimental for learning when they were presented in isolation. However, learning was enhanced when internal focus instructions were presented along with directionally neutral cues in the context of the expert modeled cue structure. Given these findings, future research is needed to test more realistic instructional approaches and move beyond the traditional, dichotomous instructions that have been used in previous studies. The present findings also reinforce the essential role of coaches in guiding athletes toward advantageous attentional focus choices. Although the participants in Study 2 were seasoned athletes with an average of nearly 10 years of experience, they were not able to elicit learning benefits through autonomous attentional focus selections. It may be that their effective use of autonomy was compromised by distractions or by the provision of too many choices. Future work is necessary to gain a more comprehensive understanding of coaching strategies, including manageable levels of attentional autonomy and well-rounded instructional approaches, to optimize learning for athletes of all levels.

REFERENCES

Abdollahipour, R., Land, W. M., Cereser, A., & Chiviacowsky, S. (2019). External relative to internal attentional focus enhances motor performance and learning in visually impaired individuals. *Disability and Rehabilitation*. doi:10.1080/09638288.2019.1566408

Abdollahipour, R., Nieto, M. P., Psotta, R., & Wulf, G. (2017). External focus of attention and autonomy support have additive benefits for motor performance in children. *Psychology of Sport and Exercise, 32*, 17-24. doi:10.1016/j.psychsport.2017.05.004

Abdollahipour, R., Wulf, G., Psotta, R., & Nieto, M. P. (2015). Performance of gymnastics skill benefits from an external focus of attention. *Journal of Sports Sciences, 33*(17), 1807-1813. doi:10.1080/02640414.2015.1012102

Agar, C., Humphries, C. A., Naquin, M., Hebert, E., & Wood, R. (2016). Does varying attentional focus affect skill acquisition in children? A comparison of internal and external focus instructions and feedback. *The Physical Educator, 73*, 639-651.

Aiken, C. A., Fairbrother, J. T., & Post, P. G. (2012). The effects of self-controlled video feedback on the learning of the basketball set shot. *Frontiers in Psychology, 3*, 1-8. doi:10.3389/fpsyg.2012.00338

Arent, S. M., & Landers, D. M. (2003). Arousal, anxiety, and performance: A reexamination of the inverted-U hypothesis. *Research Quarterly for Exercise and Sport, 74*(4), 436-444. doi:10.1080/02701367.2003.10609113

Asadi, A., Farsi, A., Abdoli, B., Saemi, E., & Porter, J. M. (2019). Directing attention externally and self-controlled practice have similar effects on motor skill performance. *Journal of Motor Learning and Development, 7*(141-151). doi:10.1123/jmld.2017-0027

Baniasadi, T., Namazizadeh, M., & Sheikh, M. (2018). Attentional focus can affect sway in postural and supra-postural tasks in community-dwelling older adults. *Annals of Applied Sport Science, 6*(3), 31-37. doi:10.29252/aassjournal.6.3.31

Becker, K. A., Beorges, A. F., & Aiken, C., A. (2019). Considering a holistic focus of attention as an alternative to an external focus. *Journal of Motor Learning and Development, 7*, 194-203. doi:10.1123/jmld.2017-0065

Becker, K. A., & Fairbrother, J. T. (2019). The use of multiple externally directed attentional focus cues facilitates motor learning. *International Journal of Sports Science & Coaching, 14*(5), 651-657. doi:10.1177/1747954119870172

Becker, K. A., Fairbrother, J. T., & Couvillion, K. F. (2018). The effects of attentional focus in the preparation and execution of a standing long jump. *Psychological Research*. doi:10.1007/s00426-018-0999-2

Becker, K. A., & Smith, P. J. K. (2015). Attentional focus effects in standing long jump performance: Influence of a broad and narrow internal focus. *Journal of Strength & Conditioning Research, 29*(7), 1780-1783.

Bernier, M., Codron, R., Thienot, E., & Fournier, J. F. (2011). The attentional focus of expert golfers in training and competition: A naturalistic investigation. *Journal of Applied Sport Psychology, 23*(3), 326-341.

Bernier, M., Trottier, C., Thienot, E., & Fournier, J. (2016). An investigation of attentional foci and their temporal patterns: A naturalistic study in expert figure skaters. *The Sport Psychologist, 30*, 256-266.

Bernstein, N. A. (1996). On dexterity and its development. In M. L. Latash & M. T. Turvey (Eds.), *Dexterity and its development* (pp. 3-246). Mahwah, NJ: Lawrence Erlbaum.

Brocken, J. E. A., Kal, E. C., & Kamp, J. v. d. (2016). Focus of attention in children's motor learning: Examining the role of age and working memory. *Journal of Motor Behavior, 48*(6), 527-534. doi:10.1080/00222895.2016.1152224

Bruin, E. D. d., Swanenburg, J., Betschon, E., & Murer, K. (2009). A randomised controlled trial investigating motor skill training as a function of attentional focus in old age. *BMC Geriatrics, 9*(15). doi:10.1186/1471-2318-9-15

Carpenter, S. K., Lohse, K. R., Healy, A. F., Jr., L. E. B., & Clegg, B. A. (2013). External focus of attention improves performance in a speeded aiming task. *Journal of Applied Research in Memory and Cognition, 2*, 14-19. doi:10.1016/j.jarmac.2012.11.002

Carter, M. J., & Ste-Marie, D. M. (2017). An interpolated activity during the knowledge-of-results delay interval eliminates the learning advantages of self-controlled feedback schedules. *Psychological Research, 81*, 399-406.

Castaneda, B., & Gray, R. (2007). Effects of focus of attention on baseball batting performance in players of differing skill levels. *Journal of Sport & Exercise Psychology, 29*, 60-77.

Cattell, J. M. (1947). Attention and reaction (R. S. Woodworth, Trans.). In *James McKeen Cattell, Man of Science* (Vol. 1, pp. 252-255). Lancaster, PA: The Science Press. Original work published in 1983.

Chiviacowsky, S., & Wulf, G. (2005). Self-controlled feedback is effective if it is based on the learner's performance. *Research Quarterly for Exercise and Sport, 76*(1), 42-48.

Chiviacowsky, S., Wulf, G., & Avila, L. T. G. (2012). An external focus of attention enhances motor learning in children with intellectual disabilities. *Journal of Intellectual Disability Research, 57*(7), 627-634. doi:10.1111/j.1365-2788.2012.01569.x

Chiviacowsky, S., Wulf, G., & Lewthwaite, R. (2012). Self-controlled learning: The importance of protecting perceptions of competence. *Frontiers in Psychology, 3*. doi:10.3389/fpsyg.2012.00458

Chiviacowsky, S., Wulf, G., Lewthwaite, R., & Campos, T. (2012). Motor learning benefits of self-controlled practice in persons with Parkinson's disease. *Gait & Posture, 35*, 601-605. doi:10.1016/j.gaitpost.2011.12.003

Chiviacowsky, S., Wulf, G., & Wally, R. (2010). An external focus of attention enhances balance learning in older adults. *Gait & Posture, 32*, 572-575.

Chow, V. W. K., Ellmers, T. J., Young, W. R., Mak, T. C. T., & Wong, T. W. L. (2019). Revisiting the relationship between internal focus and balance control in young and older adults. *Frontiers in Neurology, 9*. doi:10.3389/fneur.2018.01131

Chua, T. X., Sproule, J., & Timmons, W. (2018). Effect of skilled dancers' focus of attention on pirouette performance. *Journal of Dance Medicine & Science, 22*(3), 148-159. doi:10.12678/1089-313X.22.3.148

Cleary, T. J., & Zimmerman, B. J. (2001). Self-regulation differences during athletic practice by experts, non-experts, and novices. *Journal of Applied Sport Psychology, 13*, 185-206.

Coker, C. (2016). Optimizing external focus of attention instructions: The role of attainability. *Journal of Motor Learning and Development, 4*, 116-125.

Coker, C. (2019). Combining Attentional Focus Strategies: Effects and Adherence. *The Physical Educator, 76*, 98-109. doi:10.18666/TPE-2019-V76-I1-8520

Couvillion, K. F., Bass, A. D., & Fairbrother, J. T. (2020). Increased cognitive load during acquisition of a continuous task eliminates the learning effects of self-controlled knowledge of results. *Journal of Sports Sciences, 38*(1), 94-99. doi:10.1080/02640414.2019.1682901

Couvillion, K. F., & Fairbrother, J. T. (2018). Expert and Novice Performers Respond Differently to Attentional Focus Cues for Speed Jump Roping. *Frontiers in Psychology, 9*. doi:10.3389/fpsyg.2018.02370

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry, 11*(4), 227-268.

Deutsch, J. A., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Review, 70*, 80-90.

Diekfuss, J. A., & Raisbeck, L. D. (2016). Focus of Attention and Instructional Feedback from NCAA Division 1 Collegiate Coaches. *Journal of Motor Learning and Development*(4), 262-273.

Diekfuss, J. A., Rhea, C. K., Schmitz, R. J., Grooms, D. R., Wilkins, R. W., Slutsky, A. B., & Raisbeck, L. D. (2019). The influence of attentional focus on balance control over seven days of training. *Journal of Motor Behavior, 0*(0), 1-12.

Donders, F. C. (1969). On the speed of mental processes. In *W.G. Koster (Ed. & Trans.), Attention and performance II*. Amsterdam: North-Holland: (Original work published in 1868).

Duda, J. L., & Treasure, D. C. (2015). The Motivational Climate, Athlete Motivation, and Implications for the Quality of Sport Engagement. In J. M. Williams & V. Krane (Eds.), *Applied Sport Psychology* (7th ed., pp. 57-77). New York, NY: McGraw-Hill.

Eccles, D. W., & Arsal, G. (2017). The think aloud method: what is it and how do I use it? *Qualitative Research in Sport, Exercise and Health, 9*(4), 514-531. doi:10.1080/2159676X.2017.1331501

Emanuel, M., Jarus, T., & Bart, O. (2008). Effect of focus of attention and age on motor acquisition, retention, and transfer: A randomized trial. *Physical Therapy, 88*(2), 251-260.

Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3). doi:10.1037/0033-295X.100.3.363

Fairbrother, J. T., Laughlin, D. D., & Nguyen, T. V. (2012). Self-controlled feedback facilitates motor learning in both high and low activity individuals. *Frontiers in Psychology, 3*. doi:10.3389/fpsyg.2012.00323

Fairbrother, J. T., Post, P. G., & Whalen, S. J. (2016). Self-reported responses to player profile questions show consistency with the use of complex attentional strategies by expert horseshoe pitchers. *Frontiers in Psychology, 7*(1028).

Fairbrother, J. T., & Woodard, K. F. Attentional focus effects on performance and learning of double dutch. *Manuscript in preparation*.

Fitts, P. M., & Posner, M. I. (1967). *Human performance*. Oxford, England: Brooks/Cole.

Flores, F. S., Schild, J. F. G., & Chiviacowsky, S. (2015). Benefits of external focus instructions on the learning of a balance task in children of different ages. *International Journal of Sport Psychology, 46*, 311-320. doi:10.7352/IJSP2015.46.311

Gallwey, W. T. (2014). *The inner game of tennis: The ultimate guide to the mental side of peak performance*: Pan Macmillan.

Gentile, A. M. (1972). A working model of skill acquisition with application to teaching. *Quest, 17*(1), 3-23. doi:10.1080/00336297.1972.10519717

Greifeneder, R., Scheibehenne, B., & Kleber, N. (2010). Less may be more when choosing is difficult: Choice complexity and too much choice. *Acta Psychologica, 133*, 45-50. doi:10.1016/j.actpsy.2009.08.005

Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behavior, 36*(2), 212-224. doi:10.3200/JMBR.36.2.212-224

Guss-West, C., & Wulf, G. (2016). Attentional focus in classical ballet: A survey of professional dancers. *Journal of Dance Medicine & Science, 20*(1), 23-29.

Hadler, R., Chiviacowsky, S., Wulf, G., & Schild, J. F. G. (2014). Children's learning of tennis skills is facilitated by external focus instructions. *Motriz. Revista de Educacao Fisica, 20*(4), 418-422. doi:10.1590/S1980-65742014000400008

Halperin, I., Chapman, D. W., Martin, D. T., Lewthwaite, R., & Wulf, G. (2017). Choices enhance punching performance of competitive kickboxers. *Psychological Research.*

Halperin, I., Williams, K. J., Martin, D. T., & Chapman, D. W. (2016). The effects of attentional focusing instructions on force production during the isomentric midthigh pull. *Journal of Strength & Conditioning Research, 30*(4), 919-923.

Hanin, Y. L., & Stambulova, N. B. (2002). Metaphoric description of performance states: An applicaiton of the IZOF model. *The Sport Psychologist, 16*, 396-415.

Harleb, E. (1861). Der Apparat des Willens. *Zeitschrift für Philosophie und philosophische Kritik, 38*, 50-73.

Hebert, E. P., & Williams, B. M. (2017). Effects of three types of attentional focus on standing long jump performance. *Journal of Sport Behavior, 40*(2), 156-170.

Hitchcock, D. R., & Sherwood, D. E. (2018). Effects of Changing the Focus of Attention on Accuracy, Acceleration, and Electromyography in Dart Throwing. *International Journal of Exercise Science, 11*(1), 1120-1135.

Hommel, B., Musseler, J., Aschersleben, G., & Prinz, W. (2001). The Theory of Event Coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849-937. doi:10.1017/S0140525X01000103

International Jump Rope Union (2019). *IJRU Rule Book* [1.1.0] *Judging Manual*.

Jackson, B. H., & Holmes, A. M. (2011). The effects of focus of attention and task objective consistency on learning a balancing task. *Research Quarterly for Exercise and Sport, 82*(3), 574-579. doi:10.1080/02701367.2011.10599791

James, W. (1890). *The principles of psychology*. New York: Holt.

Kahneman, D. (1973). *Attention and effort* (Vol. 1063). Englewood Cliffs, NJ: Prentice-Hall.

Kal, E. C., van der Kamp, J., & Houdijk, H. (2013). External attentional focus enhances movement automatization: A comprehensive test of constrained action hypothesis. *Human Movement Science, 32*, 527-539. doi:10.1016/j.humov.2013.04.001

Keele, S. W. (1973). *Attention and human performance*. Pacific Palisades, CA: Goodyear.

Koch, I., Keller, P., & Prinz, W. (2004). The Ideomotor approach to action control: Implications for skilled performance. *International Journal of Sport and Exercise Psychology, 2*(4), 362-375. doi:10.1080/1612197X.2004.9671751

Kramer, A. F., Wiegmann, D. A., & Kirlik, A. (2006). *Attention: From theory to practice*: Oxford University Press.

Land, W. M., Frank, C., & Schack, T. (2014). The influence of attentional focus on the development of skill representation in a complex action. *Psychology of Sport and Exercise, 15*, 30-38. doi:10.1016/j.psychsport.2013.09.006

Laughlin, D. D. (2012). *Control over multiple forms of instructional assistance while learning the cascade juggle.* (PhD). University of Tennessee, Retrieved from https://trace.tennessee.edu/utk_graddiss/1319

Lawrence, G. P., Gottwald, V. M., Hardy, J., & Khan, M. A. (2011). Internal and external focus of attention in a novice form sport. *Research Quarterly for Exercise and Sport, 82*(3), 431-441.

Lawrence, G. P., Gottwald, V. M., Khan, M. A., & Kramer, R. S. S. (2012). The movement kinematics and learning strategies associated with adopting different foci of attention during both acquisition and anxious performance. *Frontiers in Psychology, 3*. doi:10.3389/fpsyg.2012.00468

Lawrence, G. P., Virian, J., Oliver, S. J., & Gottwald, V. M. (2019). Lets go surfing now, everybody's learning how; attentional strategies on expert and novice surfing performance under both practice and competition conditions. *European Journal of Sport Science*. doi:10.1080/17461391.2019.1626489

Lee, T. D., Eliasz, K. L., Gonzalez, D., Alguire, K., Ding, K., & Dhaliwal, C. (2016). On the role of error in motor learning. *Journal of Motor Behavior, 48*(2), 99-115. doi:10.1080/00222895.2015.1046545

Lewthwaite, R., Chiviacowsky, Z., Drews, R., & Wulf, G. (2015). Choose to move: The motivational impact of autonomy support on motor learning. *Psychonomic Bulletin & Review, 22*, 1383-1388.

Lohse, K. R. (2012). The influence of attention on learning and performance: Pre-movement time and accuracy in an isometric force production task. *Human Movement Science, 31*, 12-25.

Lohse, K. R., & Sherwood, D. E. (2011). Defining the focus of attention: effects of attention on perceived exertion and fatigue. *Frontiers in Psychology, 2*(332).

Lohse, K. R., & Sherwood, D. E. (2012). Thinking about muscles: The neuromuscular effects of attentional focus on accuracy and fatigue. *Acta Phsychologica, 140*, 236-245.

Lohse, K. R., Sherwood, D. E., & Healy, A. F. (2010). How changing the focus of attention affects performance, kinematics, and electromyography in dart throwing. *Human Movement Science, 29*(4), 542-555.

Lohse, K. R., Sherwood, D. E., & Healy, A. F. (2014). On the advantage of an external focus of attention: A benefit to learning or performance? *Human Movement Science, 33*, 120-134.

Lotze, R. H. (1852). *Medicinische Psychologie oder die Physiologie der Seele*. Leipzig: Weidmann'sche Buchhandlung.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*(2), 163-203.

MacPherson, A., Collins, D., & Morriss, C. (2008). Is what you think what you get? Optimizing mental focus for technical performance. *The Sport Psychologist, 22*(3), 288-303.

Magill, R. A. (2011). *Motor learning and control: Concepts and applications* (9th ed.). New York, NY: McGraw-Hill.

Magill, R. A., & Hall, K. G. (1990). A review of the contextual interference effect in motor skill acquisition. *Human Movement Science, 9*, 241-289.

Marchant, D. C., Clough, P. J., & Crawshaw, M. (2007). The effects of attentional focusing strategies on novice dart throwing performance and their task experiences. *International Journal of Sport and Exercise Psychology, 5*(3), 291-303.

Maurer, H., & Zentgraf, K. (2007). On the how and why of the external focus learning advantage. In E.-J. Hossner & N. Wenderoth (Eds.), *Wulf on attentional focus and motor learning [Target article]. E-Journal Bewegung und Training* (Vol. 1, pp. 31-32).

McCann, R. S., & Johnston, J. C. (1992). Locus of the Single-Channel Bottleneck in Dual-Task Interference. *Journal of Experimental Psychology, 18*(2), 471-484.

McNevin, N. H., Shea, C. H., & Wulf, G. (2003). Increasing the distance of an external focus of attention enhances learning. *Psychological Research, 67*, 22-29.

Miles, M. B., & Huberman, M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational Researcher, 13*(5), 20-30. doi:10.3102/0013189X013005020

Munzert, J., Maurer, H., & Reiser, M. (2014). Verbal-motor attention-focusing instructions influence kinematics and performance on a golf-putting task. *Journal of Motor Behavior, 46*(5), 309-318. doi:10.1080/00222895.2014.912197

Newell, K. M., & Slifkin, A. B. (1998). The Nature of Movement Variability. In *Motor behavior and human skill: A multidisciplinary approach* (pp. 143-160).

Nolan, R. P. (2011). *An external focus of attention enhances isometric wall sit endurance time: A quantitative and qualitative analysis of the attentional focus effect*. Southern Illinois University Carbondale, OpenSIUC.

Pashler, H., Johnston, J. C., & Ruthruff, E. (2001). Attention and performance. *Annual Review of Psychology, 52*, 629-651. doi:10.1146/annurev.psych.52.1.629

Pellechia, G. L. (2003). Postural sway increases with attentional demands of concurrent cognitive task. *Gait & Posture, 18*(1), 29-34. doi:10.1016/S0966-6362(02)00138-8

Perkins-Ceccato, N., Passmore, S. R., & Lee, T. D. (2003). Effects of focus of attention depend on golfers' skill. *Journal of Sports Sciences, 21*(8), 593-600. doi:10.1080/0264041031000101980

Perreault, M. E., & French, K. E. (2015). External-focus feedback benefits free-throw learning in children. *Research Quarterly for Exercise and Sport, 86*(4), 422-427. doi:10.1080/02701367.2015.1051613

Perreault, M. E., & French, K. E. (2016). Differences in children's thinking and learning during attentional focus instruction. *Human Movement Science, 45*, 154-160.

Poolton, J., Maxwell, J., Masters, R., & Raab, M. (2006). Benefits of an external focus of attention: Common coding or conscious processing? *Journal of Sports Sciences, 24*(1), 89-99.

Poolton, J. M., Maxwell, J. P., Masters, R. S. W., & Kamp, J. v. d. (2007). Moving with an external focus: Automatic or simply less demanding? . In E.-J. Hossner & N. Wenderoth (Eds.), *Wulf on attentional focus and motor learning [Target article]. E-Journal Bewegung und Training* (Vol. 1, pp. 43-44).

Porter, J., Makaruk, H., & Starzak, M. (2016). The role of vision and movement automization on the focus of attention effect. *Journal of Motor Learning and Development, 4*, 152-168.

Porter, J. M., Anton, P. M., Wikoff, N., M., & Ostrowski, J. B. (2013). Instructing skilled athletes to focus their attention externally at greater distances enhances jumping performance. *Journal of Strength & Conditioning Research, 27*(8), 2073-2078.

Porter, J. M., Anton, P. M., & Wu, W. F. W. (2012). Increasing the distance of an external focus of attention enhances standing long jump performance. *Journal of Strength and Conditioning Research, 26*(9), 2389-2393.

Porter, J. M., Nolan, R. P., Ostrowski, E. J., & Wulf, G. (2010). Directing attention externally enhances agility performance: a qualitative and quantitative analysis of the efficacy of using verbal instructions to focus attention. *Frontiers in Psychology, 1*. doi:10.3389/fpsyg.2010.00216

Porter, J. M., Ostrowski, E. J., Nolan, R. P., & Wu, W. F. W. (2010). Standing long-jump performance is enhanced when using an external focus of attention. *Journal of Strength & Conditioning Research, 24*(7), 1746-1750.

Porter, J. M., & Sims, B. (2013). Altering focus of attention influences elite athletes sprinting performance. *International Journal of Coaching Science, 7*(2), 41-51.

Post, P. G., Barros, J. A. C., & Wrisberg, C. A. (2011). Evidence of non-compliance with instructions in attentional focus research. *Brazilian Journal of Motor Behavior, 6*(1), 1-6.

Post, P. G., Fairbrother, J. T., & Barros, J. A. C. (2011). Self-Controlled Amount of Practice Benefits Learning of a Motor Skill. *Research Quarterly for Exercise and Sport, 82*(3), 474-481. doi:10.1080/02701367.2011.10599780

Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology, 9*(2), 129-154. doi:10.1080/713752551

Raisbeck, L. D., & Diekfuss, J. A. (2017). Verbal cues and attentional focus: A simulated target-shooting experiment. *Journal of Motor Learning and Development, 5*, 148-159. doi:10.1123/jmld.2016-0017

Reutskaja, E., & Hogarth, R. M. (2009). Satisfaction in choice as a function of the number of alternatives: When “goods satiate”. *Psychology & Marketing, 26*(3), 197-203. doi:10.1002/mar.20268

Rivadulla, A. R., Lawrenson, T., & Preatoni, E. (2018). *The effects of focus of attention on the learning of the clean weighlifting technique in novices*. Paper presented at the 36th Conference of the Internationational Society of Biomechanics in Sports, Auckland, New Zealand.

Roberts, J. W., & Lawrence, G. P. (2019). Impact of attentional focus on motor performance within the context of “early” limb regulation and “late” target control. *Acta Psychologica, 198*. doi:10.1016/j.actpsy.2019.102864

Roerdink, M., Hlavackova, P., & Vuillerme, N. (2011). Center-of-pressure regularity as a marker for attentional investment in postural control: A comparison between sitting and standing postures. *Human Movement Science, 30*(2). doi:10.1016/j.humov.2010.04.005

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Sanli, E. A., Patterson, J. T., Bray, S. R., & Lee, T. D. (2013). Understanding self-controlled motor learning protocols through the self-determination theory. *Frontiers in Psychology, 3*. doi:10.3389/fpsyg.2012.00611

Scheibehenne, B., Todd, P. M., & Greifeneder, R. (2010). Can there ever be too many options? A meta-analytic review of choice overload. *Journal of Consumer Research, 37*(3), 409-425.

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review, 82*(4), 225-260.

Schmidt, R. A., & Lee, T. D. (2011). *Motor Control and Learning: A Behavioral Emphasis* (5th ed.). Champaign, IL: Human Kinetics.

Schmidt, R. A., & Wrisberg, C. A. (2008). *Motor learning and performance: A situation-based learning approach*: Human Kinetics.

Shea, C. H., & Wulf, G. (1999). Enhancing motor learning through external-focus instructions and feedback. *Human Movement Science, 18*, 553-571.

Singer, R. N. (1988). Strategies and metastrategies in learning and performing self-paced athletic skills. *The Sport Psychologist, 2*, 49-68. doi:10.1123/tsp.2.1.49

Stambaugh, L. A. (2019). Effects of focus of attention on performance by second-year band students. *Journal of Research in Music Education, 67*(2), 233-246. doi:.o0r.g1/107.171/0770/20202424924914919883355841

Sternberg, S. (1969). The discovery of processing stages: Extensions of Donders' method. In W. G. Koster (Ed.), *Attention and performance II* (pp. 276-315). Amsterdam: North-Holland.

Stoate, I., & Wulf, G. (2011). Does the attentional focus adopted by swimmers affect their performance? *International Journal of Sports Science & Coaching, 6*(1), 99-108.

Stock, A., & Stock, C. (2004). A short history of ideo-motor action. *Psychological Research, 68*, 176-188.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

Thorn, J. E. (2006). *Using attentional strategies for balance performance and learning in nine through 12 year olds*. (Doctor of Philosophy). Florida State University, Florida State University Libraries.

Tombu, M., & Jolicceur, P. (2003). A central capacity sharing model of dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance, 29*(1). doi:10.1037/0096-1523.29.1.3

Totsika, V., & Wulf, G. (2003). The influence of external and internal foci of attention on transfer to novel situations and skills. *Research Quarterly for Exercise and Sport, 74*(2), 220-232. doi:10.1080/02701367.2003.10609084

Tsetseli, M., Zetou, E., Vernadakis, N., & Michalopoulou, M. (2016). The effect of internal and external focus of attention on game performance in tennis. *Acta Gymnica, 46*(4), 162-173. doi:10.5507/ag.2016.021

Vance, J., Wulf, G., Tollner, T., McNevin, N., & Mercer, J. (2004). EMG activity as a function of the performer's focus of attention. *Journal of Motor Behavior, 36*(4), 450-459.

Weeks, D. L., & Kordus, R. N. (1998). Relative frequency of knowledge of performance and motor skill learning. *Research Quarterly for Exercise and Sport, 69*(3), 224-230. doi:10.1080/02701367.1998.10607689

Welford, A. T. (1952). The psychological refractory period and the timing of high-speed performance - a review and a theory. *British Journal of Psychology, 43*(1).

Westphal, W., & Porter, J. M. (2013). Increasing the distance of an external focus of attention has limited effects on standing long jump performance. *International Journal of Exercise Science, 6*(4), 300-309.

White, C. M., & Hoffrage, U. (2009). Testing the tyranny of too much choice against the allure of more choice. *Psychology & Marketing, 26*(3), 280-298. doi:10.1002/mar.20273

Winkelman, N. C., Clark, K. P., & Ryan, L. J. (2017). Experience level influences the effect of attentional focus on sprint performance. *Human Movement Science, 52*, 84-95.

Woodard, K. F., & Fairbrother, J. T. (2020). Cognitive loading during and after continuous task execution alters the effects of self-controlled knowledge of results. *Frontiers in Psychology*. doi:10.3389/fpsyg.2020.01046

Wright, J. (2019). *Effect of attentional focus on learning and performance in youth sports*. (Dissertation). National Louis University, Retrieved from h<ps://digitalcommons.nl.edu/diss/378 (378)

Wrisberg, C. A. (2007). An applied sport psychological perspective on the relative merits of an external and internal focus of attention. In E.-J. Hossner & N. Wenderoth (Eds.), *Wulf on attentional focus and motor learning [Target article]. E-Journal Bewegung und Training* (Vol. 1, pp. 53-54).

Wu, W. F. W., Porter, J. M., & Brown, L. E. (2012). Effect of attentional focus strategies on peak force and performance in the standing long jump. *Journal of Strength & Conditioning Research, 26*(5), 1226-1231. doi:10.1519/JSC.0b013e318231ab61

Wulf, G. (2008). Attentional focus effects in balance acrobats. *Research Quarterly for Exercise and Sport, 79*(3), 319-325.

Wulf, G. (2013). Attentional focus and motor learning: a review of 15 years. *International Review of Sport and Exercise Psychology, 6*(1), 77-104.

Wulf, G., Chiviacowsky, S., Schiller, E., & Avila, L. T. G. (2010). Frequent external-focus feedback enhances motor learning. *Frontiers in Psychology, 1*. doi:10.3389/fpsyg.2010.00190

Wulf, G., & Dufek, J. S. (2009). Increased jump height with an external focus due to enhanced lower extremity joint kinetics. *Journal of Motor Behavior, 41*(5), 401-409.

Wulf, G., Dufek, J. S., Lozano, L., & Pettigrew, C. (2010). Increased jump height and reduced EMG activity with an external focus. *Human Movement Science, 29*, 440-448.

Wulf, G., HoB, M., & Prinz, W. (1998). Instructions for Motor Learning: Differential Effects of Internal Versus External Focus of Attention. *Journal of Motor Behavior, 30*(2), 169-179.

Wulf, G., Lauterbach, B., & Toole, T. (1999). The learning advantages of an external focus of attention in golf. *Research Quarterly for Exercise and Sport, 70*(2), 120-126.

Wulf, G., & Lewthwaite, R. (2016). Optimizing performance through intrinsic motivation and attention for learning: The OPTIMAL theory of motor learning. *Psychonomic Bulletin & Review, 23*, 1382-1414.

Wulf, G., Mcconnel, N., Gartner, M., & Schwarz, A. (2002). Enhancing the learning of sport skills through external-focus feedback. *Journal of Motor Behavior, 34*(2), 171-182. doi:10.1080/00222890209601939

Wulf, G., McNevin, N., & Shea, C. H. (2001). The automaticity of complex motor skill learning as a function of attentional focus. *The Quarterly Journal of Experimental Psychology, 54A*(4), 1143-1154.

Wulf, G., Shea, C., & Park, J.-H. (2001). Attention and motor performance: Preferences for and advantages of an external focus. *Research Quarterly for Exercise and Sport, 72*(4), 335-344. doi:10.1080/02701367.2001.10608970

Wulf, G., & Su, J. (2007). An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise and Sport, 78*(4), 384-389.

Wulf, G., Weigelt, M., Poulter, D., & McNevin, N. (2003). Attentional focus on suprapostural tasks affects balance learning. *Quarterly Journal of Experimental Psychology Section A, 56*(7), 1191-1211.

Wulf, G., Zachry, T., Granados, C., & Dufek, J. S. (2007). Increases in jump-and-reach height through an external focus of attention. *International Journal of Sports Science & Coaching, 2*(3), 275-284.

Zachry, T. (2005). *Effects of attentional focus on kinematics and muscle activation patterns as a function of expertise*. University of Nevada, Las Vegas, UNLV Retrospective Theses & Dissertations.

Zachry, T., Wulf, G., Mercer, J., & Bezodis, N. (2005). Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Research Bulletin, 67*, 304-309.

Zentgraf, K., & Munzert, J. (2009). Effects of attentional-focus instructions on movement kinematics. *Psychology of Sport and Exercise, 10*, 520-525. doi:10.1016/j.psychsport.2009.01.006

Ziv, G., & Lidor, R. (2015). Focusing attention instructions, accuracy, and quiet eye in a self-paced task—an exploratory study. *International Journal of Sport and Exercise Psychology, 13*(2), 104-120. doi:10.1080/1612197X.2014.946946

APPENDICES

Appendix A

Consent for Research Participation

Research Study Title: Exploring expert attentional focus strategies during complex skill learning

Researcher(s): Kaylee Woodard, MS, University of Tennessee, Knoxville
Jeffrey T. Fairbrother, PhD, University of Tennessee, Knoxville

---

Why am I being asked to be in this research study?

We are asking you to be in this research study because you:

1. Have worked professionally as a jump rope performer, and/or
2. have earned 1st, 2nd, or 3rd place at the 2017, 2018, and/or 2019 Grand World Jump Rope Championships in any Single Rope Freestyle event, and
3. are currently training in single rope freestyle, and
4. are at least 14 years old.

What is this research study about?

The purpose of the research study is to explore the ways in which expert jump rope athletes focus their attention during the process of learning new jump rope skills.

How long will I be in the research study?

The study will last for a maximum of three weeks. It will involve two interviews as well as several practice sessions with a brief survey after each session. Each survey is estimated to take approximately 15 minutes to complete. The interviews will take place either virtually via a secure video conference platform or in person. The first interview will take place directly prior to your first practice session and is anticipated to last approximately 30 minutes. The final interview is anticipated to last approximately 1 hour and will take place within one week of your final practice session. The full practice phase of the study lasts for two weeks. It will be <u>suggested</u> that you complete four or more practice sessions throughout these two weeks, but ultimately, the <u>number and duration</u> of practice sessions that you complete will be <u>up to you</u>. You should base these decisions on your personal training goals.

What will happen if I say "Yes, I want to be in this research study"?

If you agree to be in this study, we will ask you to:

Practice three single rope freestyle skills of your choice (one multiple under, one power skill, and one rope manipulation skill), complete two interviews, and several surveys.

After choosing the skills you'd like to practice, you will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview you in person, the interview will take place via a secure video conference platform or phone call. After the initial interview, you will be asked to begin your practice sessions. Remember that the number and duration of practice sessions that you complete will be <u>up to you</u>, although it is <u>recommended</u> that you complete four or more sessions. You'll be asked to provide information about what you are mentally focusing on during each practice session. Additionally, if you provide special consent (option at the end of this form), some or all of your practice sessions may be video-taped for later use by the investigators. After each practice session, you'll be asked to complete a brief survey. After your final practice session, you'll be asked to complete the exit interview via a secure online platform or a phone call. If you provide special consent, your responses to the initial and exit interviews may be audio-recorded for later use by the investigators.

Throughout the study, the researcher will be available via phone call and/or email to answer any questions you may have. The researcher will contact you one time during the practice phase to offer support. Any additional contact from the researcher will be on an as-needed basis, such as in the case that clarification is needed on a survey item response.

What happens if I say "No, I do not want to be in this research study"?

Being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your relationship with the researchers, the jump rope community, or the University of Tennessee.

What happens if I say "Yes" but change my mind later?

Even if you decide to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, all we ask is that you tell the principle investigator (Kaylee Woodard) that you would like to withdraw from the study. There will be no penalty for withdrawal and no loss of benefits to which you are otherwise entitled. Upon withdrawal from the study, all of your previously collected information and data will be promptly destroyed.

Are there any possible risks to me?

It is possible that someone could find out you were in this study or see your study information, but we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

Possible risks include potential inconvenience associated with practice sessions, surveys, and interviews, as well as the physical risks which are inherent in physical activity and jumping rope. To minimize the risk of inconvenience, you are encouraged to complete your practice sessions and post-practice surveys during times that are suitable for your schedule. Additionally, we will work to align the interviews with your schedule so as to minimize the risk of inconvenience. To minimize any physical risks, you are highly encouraged to adopt your REGULAR practice routines, including your regular warm up, resting, cool down, and flexibility procedures at each practice. You are also encouraged to choose skills which align with your own personal training goals and which you would practice on a normal basis (i.e., even aside from study participation).

We don't know of any other risks to you from being in the study.

Are there any benefits to being in this research study?

We do not expect you to benefit directly from being in this study. Your participation may help us to learn more about ideal focusing strategies during the process of learning new motor skills. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your information by storing all data securely in a locked cabinet or password protected computer. Additionally, no reference will be made in oral or written reports that could link you to your performance or to the study. Any information that can link participants with their data, including all audio recordings and video recordings, will be destroyed at the end of the study. Data will be retained for use in publications, presentations, and teaching. If information from this study is published or presented at scientific meetings, your name and other personal information will not be used.
We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information or what information came from you. Although it is unlikely, there are times when others may need to see the information we collect about you. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.
- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my information after this study is over?

We will keep your data to use for future research and teaching activities. Your name and other information that can directly identify you will be deleted from your research data collected as part of the study.
We may share your research data with others without asking for your consent again, but it will not contain information that could directly identify you. This sharing may be with other researchers or for purposes related to publishing research reports. Many journals now require authors to make data available to editors, reviewers, or other researchers if requested. Some journals also require depositing data in a public or other repository for later access. In any of the previously described cases, the shared data will not contain any information that can be used to identify you or connect you to your participation in the study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the lead researchers, Kaylee Woodard, MS, **kcouvill@vols.utk.edu**, (225) 278-4403; Jeffrey T. Fairbrother, Ph.D., **jfairbr1@utk.edu**, (865) 974-3616. For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: **utkirb@utk.edu**

STATEMENT OF CONSENT

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am agreeing to be in this study. I will receive a copy of this document after I sign it.

______________________	______________________	________
Name of Adult Participant	Signature of Adult Participant	Date

I agree to have my interviews and practice sessions audio-recorded. I understand that consenting to audio-recording is not a requirement for participation in the study.

______________________	________
Signature of Adult Participant	Date

I agree to have my practice trials video-recorded. I understand that consenting to video-recording is not a requirement for participation in the study.

______________________	________
Signature of Adult Participant	Date

Researcher Signature (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

______________________________	______________________________	__________
Name of Research Team Member	Signature of Research Team Member	Date

Appendix B

Permission for Research Participation of a Minor

Research Study Title: Exploring expert attentional focus strategies during complex skill learning

Researcher(s): Kaylee Woodard, MS, University of Tennessee, Knoxville
Jeffrey T. Fairbrother, PhD, University of Tennessee, Knoxville

---

Why is my child being asked to be in this research study?

We are asking your child to be in this research study because he/she:

1. Has worked professionally as a jump rope performer, and/or
2. has earned 1st, 2nd, or 3rd place at the 2017, 2018, and/or 2019 Grand World Jump Rope Championships in any Single Rope Freestyle event, and
3. is currently training in single rope freestyle, and
4. is at least 14 years old.

What is this research study about?

The purpose of the research study is to explore the ways in which expert jump rope athletes focus their attention during the process of learning new jump rope skills.

How long will my child be in the research study?

If you give permission for your child to be in the study, and your child agrees, their participation will last for a maximum of three weeks. It will involve two interviews as well as several practice sessions with a brief survey after each session. Each survey is estimated to take approximately 15 minutes to complete. The interviews will take place either virtually via a secure video conference platform or in person. The first interview will take place directly prior to the first practice session and is anticipated to last approximately 30 minutes. The final interview is anticipated to last approximately 1 hour and will take place within one week of the final practice session. The full practice phase of the study last for two weeks. It will be <u>suggested</u> to your child that they complete four or more practice sessions throughout these two weeks, but ultimately, the <u>number and duration</u> of practice completed will be <u>up to your child</u>. They will be told that they should base these decisions on their personal training goals.

What will happen if I say "Yes, I want my child to be in this research study"?

If you give permission for your child to be in this study, we will ask your child to:

Practice three single rope freestyle skills of your choice (one multiple under, one power skill, and one rope manipulation skill), complete two interviews, and several surveys.

After your child chooses the skills they'd like to practice, they will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview your child in person, the interview will take place via a secure video conference platform or phone call. After the initial interview, your child will be asked to begin your practice sessions. Remember that the number and duration of practice sessions completed will be up to your child, although it is recommended that your child completes four or more sessions. Your child will also be asked to provide information about what they are mentally focusing on during each practice session. Additionally, if you provide special consent (option at the end of this form), some or all of your child's practice sessions may be video-taped for later use by the investigators. After each practice session, they'll be asked to complete a brief survey. After the final practice session, your child will be asked to complete the exit interview via a secure online platform or via phone call. If you provide special consent, your child's responses to the initial and exit interviews may be audio-recorded for later use by the investigators.

Throughout the study, the researcher will be available via phone call and/or email to answer any questions you or your child may have. The researcher will contact your child one time during the practice phase to offer support. Any additional contact from the researcher will be on an as-needed basis, such as in the case that clarification is needed on a survey item response.

What happens if I say "No, I do not want my child to be in this research study"?

Your child's being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your relationship with the researchers, the jump rope community, or the University of Tennessee.

What happens if I say "Yes" but change my mind later?

Even if you decide to allow your child to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, all we ask is that you tell the principle investigator (Kaylee Woodard) that you would like to withdraw from the study. There will be no penalty for withdrawal and no loss of benefits to which you or your child are otherwise entitled. Upon withdrawal from the study, all of your previously collected information and data will be promptly destroyed.

Are there any possible risks to my child?

It is possible that someone could find out you were in this study or see your study information, but we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

Possible risks include potential inconvenience associated with practice sessions, surveys, and interviews, as well as the physical risks which are inherent in physical activity and jumping rope. To minimize the risk of inconvenience, you are encouraged to complete your practice sessions and post-practice surveys during times that are suitable for your schedule. Additionally, we will work to align the interviews with your schedule so as to minimize the risk of inconvenience. To minimize any physical risks, you are highly encouraged to adopt your REGULAR practice routines, including your regular warm up, resting, cool down, and flexibility procedures at each practice. You are also encouraged to choose skills which align with your own personal training goals and which you would practice on a normal basis (i.e., even aside from study participation).

We don't know of any other risks to you from being in the study.

Are there any benefits to being in this research study?

We do not expect your child to benefit from being in this study. Your child's participation may help us to learn more about ideal focusing strategies during the process of learning new motor skills. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your child's information by storing all data securely in a locked cabinet or password protected computer. Additionally, no reference will be made in oral or written reports that could link your child to their performance or to the study. Any information that can link participants with their data, including all audio recordings and video recordings, will be destroyed at the end of the study. Data will be retained for use in publications, presentations, and teaching. If information from this study is published or presented at scientific meetings, your child's name and other personal information will not be used.
We will make every effort to prevent anyone who is not on the research team from knowing you're your child gave us information or what information came from your child. Although it is unlikely, there are times when others may need to see the information we collect about your child. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.
- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my child's information after this study is over?

We will keep your child's data to use for future research and teaching activities. Your child's name and other information that can directly identify them will be deleted from your research data collected as part of the study.
We may share your child's research data with others without asking for your consent again, but it will not contain information that could directly identify your child. This sharing may be with other researchers or for purposes related to publishing research reports. Many journals now require authors to make data available to editors, reviewers, or other researchers if requested.

Some journals also require depositing data in a public or other repository for later access. In any of the previously described cases, the shared data will not contain any information that can be used to identify your child or connect them to their participation in the study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the lead researchers, Kaylee Woodard, MS, **kcouvill@vols.utk.edu**, (865) 974-8183; Jeffrey T. Fairbrother, Ph.D., **jfairbr1@utk.edu**, (865) 974-3616. For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

STATEMENT OF PERMISSION

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am giving permission for my child to be in this study. I will receive a copy of this document after I sign it.

Child's Name (printed) ____

Parent's Name (printed) ____

Parent's Signature ____ Date ______________

Permission for use of images
I agree that video recordings of my child may be created and analyzed for research purposes.

Parent's Signature ____ Date ______________

Permission for use of audio
I agree that voice recordings of my child may be created and analyzed for research purposes.

Parent's Signature ____ Date ______________

Researcher Signature (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

Name of Research Team Member	Signature of Research Team Member	Date

Appendix C

ASSENT TO PARTICIPATE IN RESEARCH

Exploring expert attentional focus strategies during complex skill learning

1. My name is Kaylee Woodard.

2. We are asking you to take part in a research study because we are trying to learn more about how high level jump rope athletes focus their attention while they learn new jump rope skills.

3. If you agree to be in this study, we will ask you to:

   Practice three single rope skills of your choice (one multiple under, one power skill, and one rope manipulation skill), complete two interviews, and some surveys.

   After choosing the skills you'd like to practice, you will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview you in person, the interview will take place over the phone or online through a secure video conference. After the initial interview, you will be asked to begin your practice sessions. You'll then have the next two weeks to practice these skills. <u>The number and length of practice sessions you complete will be up to you</u>, even though we recommend that you complete four or more sessions. You'll also be asked to provide information about what you are mentally focusing on during each practice session. If you give us permission, some or all of your practices may be video-taped for future use by the researcher. After each practice session, you'll be asked to complete a survey. Within one week following your final practice session, there will be one additional interview, called an "exit" interview to be completed over the phone or online through a secure video conference. If you give us permission, your responses in the initial and exit interviews may be voice recorded for later use by the researcher.

   Throughout the study, you can contact the researcher at any time by phone call and/or email. The researcher will contact you one time during the practice phase to answer any questions you may have. The researcher may contact you more than once if needed. For example, the researcher may contact you if an explanation is needed for a survey item response.

4. Being a part of this research project involves the risks that you normally experience during jump rope practices, including the risk of injury. So that this risk is not any greater than what you experience in your regular practices, we highly encourage you to use your normal warm up, rest time, cool down, and stretching routines throughout the project. You are also encouraged to choose skills that you would normally be practicing, even apart from the project.

   Another possible risk is that it may be inconvenient for you to complete practice sessions, surveys, and interviews. To minimize this risk, you will be able to complete all practice sessions and post-practice surveys at your convenience. In other words, we will not schedule any practices for you. Also, we will work with you to schedule interviews at times that work with your schedule.

Finally, it is possible that others could find out that you were involved in this study or see your study information. We believe that this risk is small because we take steps to protect your information, such as storing all of your data and information in a password-protected computer or a locked cabinet.

5. We do not think that you will be personally helped by being a part of this project, but we think that we can use your answers to help identify good attentional focusing strategies for jump ropers and other athletes in the future.

6. Please talk this over with your parents before you decide whether or not to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.

7. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you don't want to participate or even if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me (225) 278-4403, email me (kcouvill@vols.utk.edu), or ask me next time you see me.

    5. Signing your name below means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

____________________________________ ____________________

Name of Subject Date

10. Signing your name below means that you also agree to have your practice sessions video-taped.

____________________________________ ____________________

Name of Subject Date

11. Signing your name below means that you also agree to have your interview responses voice recorded.

____________________________________ ____________________

Name of Subject Date

Appendix D

Overview of Experimental Procedures – Experiment 1

The following script will be presented to expert participants prior to the first session.

Thank you for agreeing to take part in this study. I want to give you an overview of the study again and be sure that you understand the details of what we'll be doing. If at any point you have questions, feel free to ask. The study will involve two interviews, several practice sessions (the exact number of sessions to be decided by you), and a brief survey following each practice session.

Throughout the study, you'll be practicing three skills of your choice, one rope manipulation skill, one power skill, and one multiple under skill. You should be sure to practice these skills according to your regular practice habits and routines, including your regular warm up, rest times, cool down, etc. I want you to practice and learn the skills just as you usually would.

The study will last a maximum of three weeks – two weeks of practice, and a maximum of one week between the last practice and the final interview. As a general suggestion, you may want to practice each skill during four or more sessions over that time period. You may want to practice all three skills during a single session, or you may choose to distribute them. It is also suggested that you try to practice these skills by yourself to the extent that is feasible. This is just so that other teammates and coaches will not influence your practice or cause distractions. However, practicing solo is not a requirement for the study. One more suggestion is that you videotape your practice sessions for reference by the researcher. Again, videotaping your practices is not a requirement for the study.

The purpose of the study is for me to gain insight into your natural thoughts and focus patterns as you practice and learn skills. To gain this information, I'll ask you to simply tell me what you mentally focused on as you prepared for each practice repetition and what you focused on as you actually performed each repetition. During sessions when I'm not there with you, you'll be able to either write down or voice record your focus information. When you are telling me or making notes about your focus, I'd like you to be as honest as possible. That means that if you cannot remember your focus or you didn't focus on anything specific, you should simply say that. It also means that I do not want you to change your focus because of these questions or because you want to have something to tell me. I'm simply interested in understanding your <u>natural</u> focus patterns. You should explain your thoughts and foci in whatever terms make the most sense to you personally, and I will ask questions to clarify if needed. One more important thing to remember is that "focus" in this study is related to your <u>mental</u> focus, <u>not</u> on what you look at or visually concentrate on.

After each practice, I'll ask you to send me your written or recorded attentional information, any video recordings you'd like to send (remember these are not required!), and your completed survey. Please be sure not to include your name on any documents. Also, we'll *use UT Vault to send all of these materials. This is a secure system, and I'll show you how to use it. It's very simple.*

Do you have any questions so far? [time given for questions]

Lastly, let's talk about the skills you'd like to practice during the study. Remember that you should select one skill in each element (rope manipulation, power, and multiples). Ideally, these should be skills that you would be working on even apart from this study. They should also be skills that you have not yet mastered but that you feel you are capable of achieving within this year's competition cycle. As a general guideline, you may want to select skills that you can currently complete between 5 and 20% of the time.

[At this time, the participant and the researcher will discuss potential skills and determine the three skills which will be practiced during the study. The ultimate decision will be left to the participant, but the researcher will be available to provide guidance as necessary.]

Appendix E

Initial Interview Guide – Experiment 1

"I'm going to ask you a few general questions about yourself, your experiences with jump rope, and the skills you've chosen to work on during this study. Please do your best to answer these questions, and feel free to ask for clarification if needed."

1. What is your current age?
2. What is your gender?
3. How many years have you been involved with the sport of jump rope?
4. How would you describe your practice and training patterns throughout the seasons of a typical competition cycle?
5. Please describe the rope manipulation skill you've chosen to practice during the study?
6. What percentage of the time do you feel that you can successfully complete this skill right now?
7. What aspects of this skill do you feel are/will be the most challenging for you?
    a. The least challenging?
8. Please describe the power skill you've chosen to practice during the study?
9. What percentage of the time do you feel that you can successfully complete this skill right now?
10. What aspects of this skill do you feel are/will be the most challenging for you?
    a. The least challenging?
11. Please describe the multiple under skill you've chosen to practice during the study?
12. What percentage of the time do you feel that you can successfully complete this skill right now?
13. What aspects of this skill do you feel are/will be the most challenging for you?
    a. The least challenging?
14. Is there anything else you'd like to add?

Appendix F

Post-Practice Survey – Experiment 1

1. Which skill or skills did you practice today?

2. Did you practice these skills in any particular order?

   ____ Yes ____ No

   If yes, please describe the order you used.

3. What do you feel went well during today's practice?

4. What, if anything, did not go so well during today's practice?

5. Do you feel that you improved or learned anything during today's practice? If so, in what ways?

6. Is there anything else you'd like to tell me about today's practice session?

Appendix G

Attention Log

Please record brief notes below following each practice repetition. If additional space is needed, please use the back of the page or a separate sheet. Remember that you will have the opportunity to discuss your foci with the researcher if you so choose, so you do not need to fully explain your thoughts or foci on the log.

Rep #	Skill	Mental Focus During **Preparation**	Mental Focus During **Execution**	Additional Thoughts/Notes
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				

14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Appendix H

Exit Interview Guide – Experiment 1

1. Please describe your overall practice experience throughout the study.
2. Please describe the rope manipulation skill you chose to practice during the study.
3. What percentage of the time do you feel that you can successfully complete this skill right now?
4. Do you feel that your ability to perform this skill has improved throughout your practices? If so, in what ways?
5. What aspects of this skill do you feel are most challenging for you currently?
    a. The least challenging?
6. How would you describe your mental focus when you perform this skill currently?
7. Do you think that your mental focus related to this skill has changed across the practice sessions in this study? If so, in what ways?
8. Please describe the power skill you chose to practice during the study.
9. What percentage of the time do you feel that you can successfully complete this skill right now?
10. Do you feel that your ability to perform this skill has improved throughout your practices? If so, in what ways?
11. What aspects of this skill do you feel are most challenging for you currently?
    a. The least challenging?
12. How would you describe your mental focus when you perform this skill currently?
13. Do you think that your mental focus related to this skill has changed across the practice sessions in this study? If so, in what ways?
14. Please describe the multiple under skill you chose to practice during the study.

15. What percentage of the time do you feel that you can successfully complete this skill right now?

16. Do you feel that your ability to perform this skill has improved throughout your practices? If so, in what ways?

17. What aspects of this skill do you feel are most challenging for you currently?

    a. The least challenging?

18. How would you describe your mental focus when you perform this skill currently?

19. Do you think that your mental focus related to this skill has changed across the practice sessions in this study? If so, in what ways?

20. Do you feel that the methods in this study (for example, the attentional logs) altered the way that you focused your attention?

    a. If so, in what ways and to what extent?

21. Do you feel that you were able to accurately report your mental focus and thoughts during the study?

    a. If not, what percentage of the time do you feel that you were *unsuccessful* in doing so?

22. Is there anything else you'd like to tell me about your focus or your experiences during this study?

Appendix I

Consent for Research Participation

Research Study Title: The effects of instructions on skill learning in jump rope athletes
Researcher(s): Kaylee Woodard, MS, University of Tennessee, Knoxville
Jeffrey T. Fairbrother, PhD, University of Tennessee, Knoxville

---

Why am I being asked to be in this research study?

We are asking you to be in this research study because you:

1. have earned one of the top 20 places in your age division in single rope freestyle or pairs freestyle at a national or international level competition during the 2017, 2018, and/or 2019 competition seasons,
2. have not yet earned one of the top three places in these freestyle events at the *Grand World Championships,*
3. are currently training in single rope freestyle, and
4. are between 14 and 39 years old.

What is this research study about?

The purpose of this research study is to investigate the effects of various instructions on the learning of complex jump rope skills.

How long will I be in the research study?

The study will last for a maximum of three weeks. The study will involve two interviews, a baseline skills assessment, a learning assessment, and four practice sessions with a brief survey after each session. Each survey is estimated to take approximately 15 minutes to complete. The interviews will take place either virtually via a secure video conference platform or in person. The first interview will take place directly prior to your baseline skills assessment and is anticipated to last approximately 30 minutes. The final interview is anticipated to last approximately 1 hour and will take place within one week of your learning assessment. The baseline and learning assessments consist of ten skill repetitions and are each anticipated to last approximately 20 minutes. After the baseline and before the learning assessment, you'll complete the practice phase. The full practice phase last for two weeks. You'll be asked to complete two practice sessions during the first week and two sessions during the second week. Each practice session will involve a maximum of 30 skill repetitions and is expected to last approximately 45 minutes.

What will happen if I say "Yes, I want to be in this research study"?

If you agree to be in this study, we will ask you to:

Practice a single rope freestyle skill of your choice (either a multiple under, a power skill, or a rope manipulation skill) during four practice sessions, complete a baseline and a learning assessment, two interviews, and four post-practice surveys.

After choosing the skill you'd like to practice, you will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview you in person, the interview will take place via a secure video conference platform or phone call. After the initial interview, you will be asked to complete your baseline assessment. This assessment will be completed in person when possible. In the case that the investigator is not able to travel to conduct your baseline assessment in person, the assessment will take place via a secure video conference platform. Next, you will begin your practice sessions (two sessions during the first week of practice and two sessions during the second week of practice). You'll be given instructional cues to follow during these sessions and will be asked to provide indication of how successfully you completed each repetition. After each practice session, you'll be asked to complete a brief survey. Within one week following the practice phase, you'll be asked to complete the learning assessment, which will be conducted in person when possible. If the investigator is not able to travel to you, the assessment will take place via secure video conference platform. Additionally, if you provide special consent (option at the end of this form), some or all of your practice sessions and assessments may be video-taped for later use by the investigators. Finally, following the learning assessment, you'll be asked to complete the exit interview via a secure online platform or a phone call. If you provide special consent, your responses to the initial and exit interviews may be audio-recorded for later transcription.

Throughout the study, the researcher will be available via phone call and/or email to answer any questions you may have. The researcher will contact you prior to some or all practice sessions to offer support and provide brief reminders of the relevant study details. Any additional contact from the researcher will be on an as-needed basis, such as in the case that clarification is needed on a survey item response.

What happens if I say "No, I do not want to be in this research study"?

Being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your relationship with the researchers, the jump rope community, or the University of Tennessee.

What happens if I say "Yes" but change my mind later?

Even if you decide to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, all we ask is that you tell the principle investigator (Kaylee Woodard) that you would like to withdraw from the study. There will be no penalty for withdrawal and no loss of benefits to which you are otherwise entitled. Upon withdrawal from the study, all of your previously collected information and data will be promptly destroyed.

Are there any possible risks to me?

It is possible that someone could find out you were in this study or see your study information, but we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

Possible risks include potential inconvenience associated with practice sessions, surveys, and interviews, as well as the physical risks which are inherent in physical activity and jumping rope. To minimize the risk of inconvenience, you are encouraged to complete your practice sessions and post-practice surveys during times that are suitable for your schedule. Additionally, we will work to align the interviews with your schedule so as to minimize the risk of inconvenience. To minimize any physical risks, you are highly encouraged to adopt your REGULAR practice routines, including your regular warm up, resting, cool down, and flexibility procedures at each practice. You are also encouraged to choose a skill which aligns with your own personal training goals and which you would practice on a normal basis (i.e., even aside from study participation).

We don't know of any other risks to you from being in the study.

Are there any benefits to being in this research study?

We do not expect you to benefit directly from being in this study. Your participation may help us to learn more about ideal focusing strategies during the process of learning new motor skills. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your information by storing all data securely in a locked cabinet or password protected computer. Additionally, no reference will be made in oral or written reports that could link you to your performance or to the study. Any information that can link participants with their data, including all audio recordings and video recordings, will be destroyed at the end of the study. Data will be retained for use in publications, presentations, and teaching. If information from this study is published or presented at scientific meetings, your name and other personal information will not be used.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information or what information came from you. Although it is unlikely, there are times when others may need to see the information we collect about you. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.
- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my information after this study is over?

We will keep your data to use for future research and teaching activities. Your name and other information that can directly identify you will be deleted from your research data collected as part of the study.

We may share your research data with others without asking for your consent again, but it will not contain information that could directly identify you. This sharing may be with other researchers or for purposes related to publishing research reports. Many journals now require authors to make data available to editors, reviewers, or other researchers if requested. Some journals also require depositing data in a public or other repository for later access. In any of the previously described cases, the shared data will not contain any information that can be used to identify you or connect you to your participation in the study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the lead researchers, Kaylee Woodard, MS, **kcouvill@vols.utk.edu**, (225) 278-4403; Jeffrey T. Fairbrother, Ph.D., **jfairbr1@utk.edu**, (865) 974-3616. For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: **utkirb@utk.edu**

STATEMENT OF CONSENT

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am agreeing to be in this study. I will receive a copy of this document after I sign it.

______________________________	______________________________	__________
Name of Adult Participant	Signature of Adult Participant	Date

I agree to have my interviews and practice sessions audio-recorded for transcription purposes. I understand that consenting to audio-recording is not a requirement for participation in the study.

Signature of Adult Participant Date

I agree to have my practice trials video-recorded. I understand that consenting to video-recording is not a requirement for participation in the study.

Signature of Adult Participant Date

Researcher Signature (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

Name of Research Team Member Signature of Research Team Member Date

Appendix J

Permission for Research Participation of a Minor

Research Study Title: The effects of instructions on skill learning in jump rope athletes
Researcher(s): Kaylee Woodard, MS, University of Tennessee, Knoxville
Jeffrey T. Fairbrother, PhD, University of Tennessee, Knoxville

---

Why is my child being asked to be in this research study?

We are asking your child to be in this research study because he/she:

1. has earned one of the top 20 places in your age division in single rope freestyle or pairs freestyle at a national or international level competition during the 2017, 2018, and/or 2019 competition seasons,
2. has not yet earned one of the top three places in these freestyle events at the *Grand World Championships,*
3. is currently training in single rope freestyle, and
4. is between 14 and 39 years old.

What is this research study about?

The purpose of this research study is to investigate the effects of various instructions on the learning of complex jump rope skills.

How long will my child be in the research study?

If you give permission for your child to be in the study, and your child agrees, their participation will last for a maximum of three weeks. The study will involve two interviews, a baseline skills assessment, a learning assessment, and four practice sessions with a brief survey after each session. Each survey is estimated to take approximately 15 minutes to complete. The interviews will take place either virtually via a secure video conference platform or in person. The first interview will take place directly prior to the baseline skills assessment and is anticipated to last approximately 30 minutes. The final interview is anticipated to last approximately 1 hour and will take place within one week of the learning assessment. The baseline and learning assessments consist of ten skill repetitions and are each anticipated to last approximately 20 minutes. After the baseline and before the learning assessment, your child will be asked to complete the practice phase. The full practice phase last for two weeks. He/she will be asked to complete two practice sessions during the first week and two sessions during the second week. Each practice session will involve a maximum of 30 skill repetitions and is expected to last approximately 45 minutes.

What will happen if I say "Yes, I want my child to be in this research study"?

If you give permission for your child to be in this study, we will ask your child to:

Practice a single rope freestyle skill of their choice (either a multiple under, a power skill, or a rope manipulation skill) during four practice sessions, complete a baseline and a learning assessment, two interviews, and four post-practice surveys.

After choosing the skill they'd like to practice, your child will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview your child in person, the interview will take place via a secure video conference platform or phone call. After the initial interview, your child will be asked to complete your baseline assessment. This assessment will be completed in person when possible. In the case that the investigator is not able to travel to conduct the baseline assessment in person, the assessment will take place via a secure video conference platform. Next, your child will begin the practice session phase of the study (two practice sessions during the first week of practice and two sessions during the second week of practice). They'll be given instructional cues to follow during these sessions and will be asked to provide indication of how successfully they completed each repetition. After each practice session, your child be asked to complete a brief survey. Within one week following the practice phase, your child be asked to complete the learning assessment, which will be conducted in person when possible. If the investigator is not able to travel to complete the assessment in person, it will take place via secure video conference platform. Additionally, if you and your child provide special consent (option at the end of this form), some or all of the practice sessions and assessments may be video-taped for later use by the investigators. Finally, following the learning assessment, they'll be asked to complete the exit interview via a secure online platform or a phone call. If you and your child provide special consent, their responses to the initial and exit interviews may be audio-recorded for later transcription.

Throughout the study, the researcher will be available via phone call and/or email to answer any questions you or your child may have. The researcher will contact your child prior to some or all practice sessions to offer support and provide brief reminders of the relevant study details. Any additional contact from the researcher will be on an as-needed basis, such as in the case that clarification is needed on a survey item response.

What happens if I say "No, I do not want my child to be in this research study"?

Your child's being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your or your child's relationship with the researchers, the jump rope community, or the University of Tennessee.

What happens if I say "Yes" but change my mind later?

Even if you decide to allow your child to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, all we ask is that you tell the principle investigator (Kaylee Woodard) that you would like to withdraw from the study. There will be no penalty for withdrawal and no loss of benefits to which you or your child are otherwise entitled. Upon withdrawal from the study, all of your previously collected information and data will be promptly destroyed.

Are there any possible risks to my child?

It is possible that someone could find out you were in this study or see your study information, but we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

Possible risks include potential inconvenience associated with practice sessions, surveys, and interviews, as well as the physical risks which are inherent in physical activity and jumping rope. To minimize the risk of inconvenience, you are encouraged to complete your practice sessions and post-practice surveys during times that are suitable for your schedule. Additionally, we will work to align the interviews with your schedule so as to minimize the risk of inconvenience. To minimize any physical risks, you are highly encouraged to adopt your REGULAR practice routines, including your regular warm up, resting, cool down, and flexibility procedures at each practice. You are also encouraged to choose skills which align with your own personal training goals and which you would practice on a normal basis (i.e., even aside from study participation).

We don’t know of any other risks to you from being in the study.

Are there any benefits to being in this research study?

We do not expect your child to benefit from being in this study. Your child's participation may help us to learn more about ideal focusing strategies during the process of learning new motor skills. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your child’s information by storing all data securely in a locked cabinet or password protected computer. Additionally, no reference will be made in oral or written reports that could link your child to their performance or to the study. Any information that can link participants with their data, including all audio recordings and video recordings, will be destroyed at the end of the study. Data will be retained for use in publications, presentations, and teaching. If information from this study is published or presented at scientific meetings, your child’s name and other personal information will not be used.
We will make every effort to prevent anyone who is not on the research team from knowing you’re your child gave us information or what information came from your child. Although it is unlikely, there are times when others may need to see the information we collect about your child. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.

- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my child's information after this study is over?

We will keep your child's data to use for future research and teaching activities. Your child's name and other information that can directly identify them will be deleted from your research data collected as part of the study.
We may share your child's research data with others without asking for your consent again, but it will not contain information that could directly identify your child. This sharing may be with other researchers or for purposes related to publishing research reports. Many journals now require authors to make data available to editors, reviewers, or other researchers if requested. Some journals also require depositing data in a public or other repository for later access. In any of the previously described cases, the shared data will not contain any information that can be used to identify your child or connect them to their participation in the study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the lead researchers, Kaylee Woodard, MS, **kcouvill@vols.utk.edu**, (865) 974-8183; Jeffrey T. Fairbrother, Ph.D., **jfairbr1@utk.edu**, (865) 974-3616. For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

STATEMENT OF PERMISSION

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am giving permission for my child to be in this study. I will receive a copy of this document after I sign it.

Child's Name (printed) ____

Parent's Name (printed) ____

Parent's Signature ____ Date _____________

Permission for use of images
I agree that video recordings of my child may be created and analyzed for research purposes.

Parent's Signature ____ Date _____________

Permission for use of audio
I agree that voice recordings of my child may be created, transcribed, and analyzed for research purposes.

Parent's Signature ____ Date _____________

Researcher Signature (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

________________________________ ____________________________________ _________

Name of Research Team Member Signature of Research Team Member Date

Appendix K

ASSENT TO PARTICIPATE IN RESEARCH

The effects of instructions on skill learning in jump rope athletes

1. My name is Kaylee Woodard.

2. We are asking you to take part in a research study because we are trying to learn more about how instructions affect the learning of freestyle jump rope skills.

3. If you agree to be in this study, we will ask you to:

   Practice a single rope skill of your choice (either a multiple under, a power skill, or a rope manipulation skill) across four practice sessions, complete four surveys, two interviews, and a baseline and learning skill assessment.

   After choosing the skill you'd like to practice, you will be asked to complete the initial interview. This will be completed in person when possible. In the case that the investigator is not able to travel to interview you in person, the interview will take place over the phone or online through a secure video conference. After the initial interview, you will be asked to complete the baseline skill assessment. This assessment will involve ten repetitions of your chosen freestyle skills. Next, you'll begin your practice sessions (two sessions during the first week of practice, and two sessions during the second week). The researcher will provide you with instructions about how to focus your attention during practice sessions. You'll also be asked to fill out a chart during practices that will indicate how successfully you feel you were able to complete each skill repetition. After each practice session, you'll be asked to complete a short survey. Within one week following your final practice session, you will be asked to complete your learning assessment, which is just like the baseline assessment, and one additional interview, called an "exit" interview. The interview and assessment will be completed in person if possible. If it is not possible for the researcher to travel to you, then we may complete the interview via a phone call or secure video conference and your learning assessment via secure video conference. If you give us permission, your initial and exit interviews may be voice recorded so that we can transcribe (that is, type out) your responses later. Additionally, if you give us permission, your baseline and learning assessments and some or all of your practice sessions may be video-taped for future use by the researcher.

   Throughout the study, you can contact the researcher at any time by phone call and/or email. The researcher will contact you prior to some or all of your practice sessions to answer any questions you may have and to provide brief reminders of the important study details. All other contact will be on an as-needed basis. For example, the researcher may contact you if an explanation is needed for a survey item response.

4. Being a part of this research project involves the risks that you normally experience during jump rope practices, including the risk of injury. So that this risk is not any greater than what you experience in your regular practices, we highly encourage you to use your normal warm up, rest time, cool down, and stretching routines throughout the project. You are also

encouraged to choose a skill that you would normally be practicing, even apart from the project.

Another possible risk is that it may be inconvenient for you to complete practice sessions, skill assessments, surveys, and interviews. To minimize this risk, you will be able to complete all practice sessions and post-practice surveys at your convenience. In other words, we will not schedule practices for you. Also, we will work with you to schedule interviews and the baseline and learning assessments at times that work well with your schedule.

Finally, it is possible that others could find out that you were involved in this study or see your study information. We believe that this risk is small because we take steps to protect your information, such as storing all of your data and information in a password-protected computer or a locked cabinet.

5. We do not think that you will be personally helped by being a part of this project, but we think that we can use your answers to help identify good attentional focusing strategies for jump ropers and other athletes in the future.

6. Please talk this over with your parents before you decide whether or not to participate. We will also ask your parents to give their permission for you to take part in this study. But even if your parents say "yes" you can still decide not to do this.

7. If you don't want to be in this study, you don't have to participate. Remember, being in this study is up to you and no one will be upset if you don't want to participate or even if you change your mind later and want to stop.

8. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me (225) 278-4403, email me (kcouvill@vols.utk.edu), or ask me next time you see me.

9. Signing your name below means that you agree to be in this study. You and your parents will be given a copy of this form after you have signed it.

____________________________________ ____________________

Name of Subject Date

10. Signing your name below means that you also agree to have your practice and assessment sessions video-taped.

____________________________________ ____________________

Name of Subject Date

11. Signing your name below means that you also agree to have your interview responses voice recorded for later transcription.

______________________________________ ____________________

Name of Subject Date

Appendix L

Overview of Experimental Procedures

The following script will be presented to participants prior to the baseline assessment.

Thank you for agreeing to take part in this study. I want to give you an overview of the study again and be sure that you understand the details of what we'll be doing. If at any point you have questions, feel free to ask. The study will involve two interviews, a baseline and a learning assessment, four practice sessions, and four brief surveys (one following each practice session).

Throughout the study, you'll be practicing one single rope freestyle skill [a multiple under, power skill, or rope manipulation skill] of your choice. You should practice this skill according to your regular practice habits, including your regular warm up, rest times, and cool down. I'll provide you with some focus instructions to follow as you complete each practice session. I'll also give you a chart to fill out during practice sessions so that you can tell me the degree to which you successfully completed each repetition. It is also suggested that you try to practice your chosen skill by yourself to the extent that is feasible. This is just so that other teammates and coaches will not influence your practice or cause distractions. However, practicing solo is not a requirement for the study. One more suggestion is that you videotape your practice sessions for reference by the researcher. Again, videotaping your practices is not a requirement for the study.

The study will last a maximum of three weeks – two weeks of practice, and a maximum of one week between the last practice and the learning assessment and final interview.

The purpose of the study is for me to gain insight into the effects of instructions on how jump rope athletes learn skills. To gain this information, it is important that you focus on the instructions I provide for you to the best of your ability during each practice repetition. One more important thing to remember is that "focus" in this study is related to your mental focus, not on what you look at or visually concentrate on.

*Before some or all of your practice sessions, I'll contact you to answer any questions you might have and to remind you of relevant study details. After each practice, I'll ask you to send me any video recordings that you'd like to send (remember these are not required!), and your completed survey. Please be sure **not** to include your name on any documents. Also, we'll use UT Vault to send all of these materials. This is a secure system, and I'll show you how to use it. It's very simple.*

Do you have any questions so far? [time given for questions]

Lastly, let's talk about the skill you'd like to practice during the study. Ideally, it should be a skill that you would be working on even apart from this study. It should also be a skill that you have not yet mastered but that you feel you are capable of achieving within this year's competition cycle. As a general guideline, you may want to select a skill that you can currently complete between 5 and 20% of the time.

[At this time, the participant and the researcher will discuss potential skills and determine the skill which will be practiced during the study. The ultimate decision will be left to the participant, but the researcher will be available to provide guidance as necessary.]

Appendix M

Initial Interview Guide

"I'm going to ask you a few general questions about yourself, your experiences with jump rope, and the skill you've chosen to practice during this study. Please do your best to answer these questions, and feel free to ask for clarity if needed."

1. What is your current age?
2. What is your gender?
3. How many years have you been involved with the sport of jump rope?
4. Please describe the skill you've chosen to practice during the study.
5. What percentage of the time do you feel that you can successfully complete this skill right now?
6. What aspects of this skill do you feel are/will be the most challenging for you?
    a. The least challenging?
7. Is there anything else you would like to add?

Appendix N

Attentional Focus Cue Structure

Practice 1	
Repetition	Cue Type
1	Movement Quality
2	Movement Quality
3	Body Position
4	Body Position
5	Speed/Timing
6	Speed/Timing
7	Height
8	Movement Quality
9	Body Position
10	Speed/Timing
11	Speed/Timing
12	Height
13	Movement Quality
14	Movement Quality
15	Speed/Timing

Practice 2	
Repetition	Cue Type
1	Speed/Timing
2	Speed/Timing
3	Movement Quality
4	Height
5	Body Position
6	Body Position
7	Movement Quality
8	Movement Quality
9	Speed/Timing
10	Speed/Timing
11	Body Position
12	Speed/Timing
13	Movement Quality
14	Movement Quality
15	Height

Practice 3	
Repetition	Cue Type
1	Speed/Timing
2	Movement Quality
3	Movement Quality
4	Body Position
5	Height
6	Speed/Timing
7	Speed/Timing
8	Movement Quality
9	Movement Quality
10	Speed/Timing
11	Height
12	Body Position
13	Movement Quality
14	Speed/Timing
15	Speed/Timing

Practice 4	
Repetition	Cue Type
1	Movement Quality
2	Movement Quality
3	Height
4	Speed/Timing
5	Speed/Timing
6	Body Position
7	Speed/Timing
8	Speed/Timing
9	Movement Quality
10	Movement Quality
11	Body Position
12	Height
13	Movement Quality
14	Speed/Timing
15	Speed/Timing

Appendix O

Example of Attentional Focus Cues Given to EM Group Member
Skill Chosen: TJEB Quadruple Under

Practice 1	
Repetition	**Focus Cue**
1	Focus on crossing big
2	Focus on crossing big
3	Focus on tucking your legs up
4	Focus on tucking your legs up
5	Focus on going fast on the side swing
6	Focus on going fast
7	Focus on jumping as high as you can
8	Focus on reaching far on the EB
9	Focus on keeping your chest up
10	Focus on going fast on the TJ
11	Focus on going fast
12	Focus on jumping as high as you can
13	Focus on making big, smooth movements
14	Focus on making big, smooth movements
15	Focus on going fast on the TJ and holding the EB long enough

Practice 2	
Repetition	**Focus Instruction**
1	Focus on going fast on the side swing
2	Focus on going fast
3	Focus on crossing big
4	Focus on jumping as high as you can
5	Focus on tucking your legs up
6	Focus on tucking your legs up
7	Focus on crossing big
8	Focus on reaching far on the EB
9	Focus on going fast on the TJ
10	Focus on going fast
11	Focus on keeping your chest up
12	Focus on going fast on the TJ and holding the EB long enough
13	Focus on making big, smooth movements
14	Focus on making big, smooth movements
15	Focus on jumping as high as you can

Practice 3	
Repetition	**Focus Instruction**
1	Focus on going fast on the TJ and holding the EB long enough
2	Focus on making big, smooth movements
3	Focus on crossing big
4	Focus on crossing big
5	Focus on jumping as high as you can
6	Focus on going fast on the TJ
7	Focus on going fast
8	Focus on crossing big
9	Focus on crossing big
10	Focus on going fast on the TJ and holding the EB long enough
11	Focus on jumping as high as you can
12	Focus on tucking your legs up
13	Focus on making big, smooth movements
14	Focus on going fast on the side swing
15	Focus on going fast

Practice 4	
Repetition	**Focus Instruction**
1	Focus on making big, smooth movements
2	Focus on crossing big
3	Focus on jumping as high as you can
4	Focus on going fast on the TJ and holding the EB long enough
5	Focus on going fast
6	Focus on keeping your chest up
7	Focus on going fast on the side swing
8	Focus on going fast on the TJ
9	Focus on crossing big
10	Focus on crossing big
11	Focus on tucking your legs up
12	Focus on jumping as high as you can
13	Focus on making big, smooth movements
14	Focus on going fast on the side swing
15	Focus on going fast

Appendix P

Example of Attentional Focus Cue Choices Given to EM-A Group Member
Skill Chosen: TJAS Quadruple Under

	Attentional Focus Cue Choices
1	Focus on crossing big
2	Focus on tucking your knees up
3	Focus on going fast on the side swing
4	Focus on going fast
5	Focus on jumping as high as you can
6	Focus on crossing big on the AS
7	Focus on keeping your chest up
8	Focus on going fast on the TJ
9	Focus on making big, smooth movements
10	Focus on going fast on the TJ and holding the AS long enough

Appendix Q

Practice Log

After each practice repetition, please check that best describes the degree to which you were able to successfully perform that repetition. If you need additional space for notes, please use the back of the page or a separate sheet.

Rep #	Successfully completed skill	Rope partially or fully passed under **one** foot on landing.	Rope partially passed under **both** feet on landing.	Rope did not pass under either foot on landing.	Notes
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					

Appendix R

Post-Practice Survey

1. What do you feel went well during today's practice?

2. What, if anything, did not go so well during today's practice?

3. Do you feel that you improved or learned anything during today's practice? If so, in what ways?

4. During what percent of repetitions do you feel that you were able to focus on the given cues during today's practice?

   □ 0-20% □ 21-40% □ 41-60% □61-80% □ 81-100%

5. What, if anything, was difficult about focusing on the cues?

6. What else, if anything, do you remember focusing on during practice?

7. Is there anything else you'd like to tell me about today's practice session?

Appendix S

Exit Interview Guide

1. Please describe your overall practice experience throughout the study.

2. Please describe the skill you chose to practice during the study.

3. What percentage of the time do you feel that you can successfully complete this skill right now?

4. Do you feel that your ability to perform this skill has improved throughout your practices? If so, in what ways?

5. What aspects of this skill do you feel are most challenging for you currently?

    a. The least challenging?

6. Do you think that your mental focus related to this skill has changed across the practice sessions in this study? If so, in what ways?

7. How would you describe your attentional focus during the post-assessment?

8. How helpful did you feel that the focus cue(s) given during the study was/were for learning the skill?

Options verbally provided:

Very helpful
Somewhat helpful
Neither helpful nor unhelpful
Somewhat unhelpful
Very unhelpful

9. Are there any other ways that you would have preferred to focus your attention during practices?

    a. If so, please describe these preferred foci.

10. Is there anything else you'd like to tell me about your focus or your experiences during this study?

Appendix T

Figures

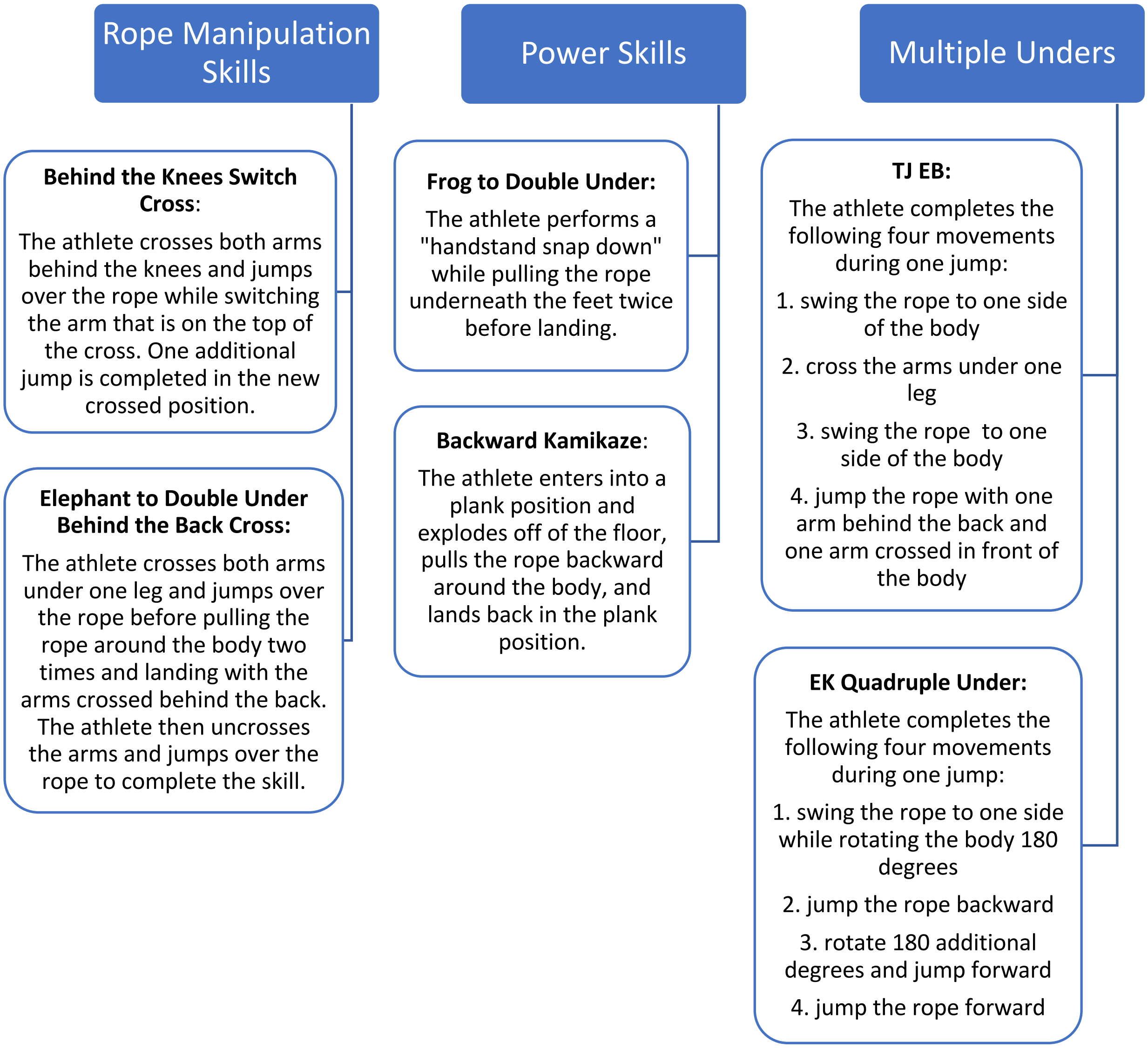

Figure 1. *Names and descriptions of example skills within each element of Single Rope Freestyle.*

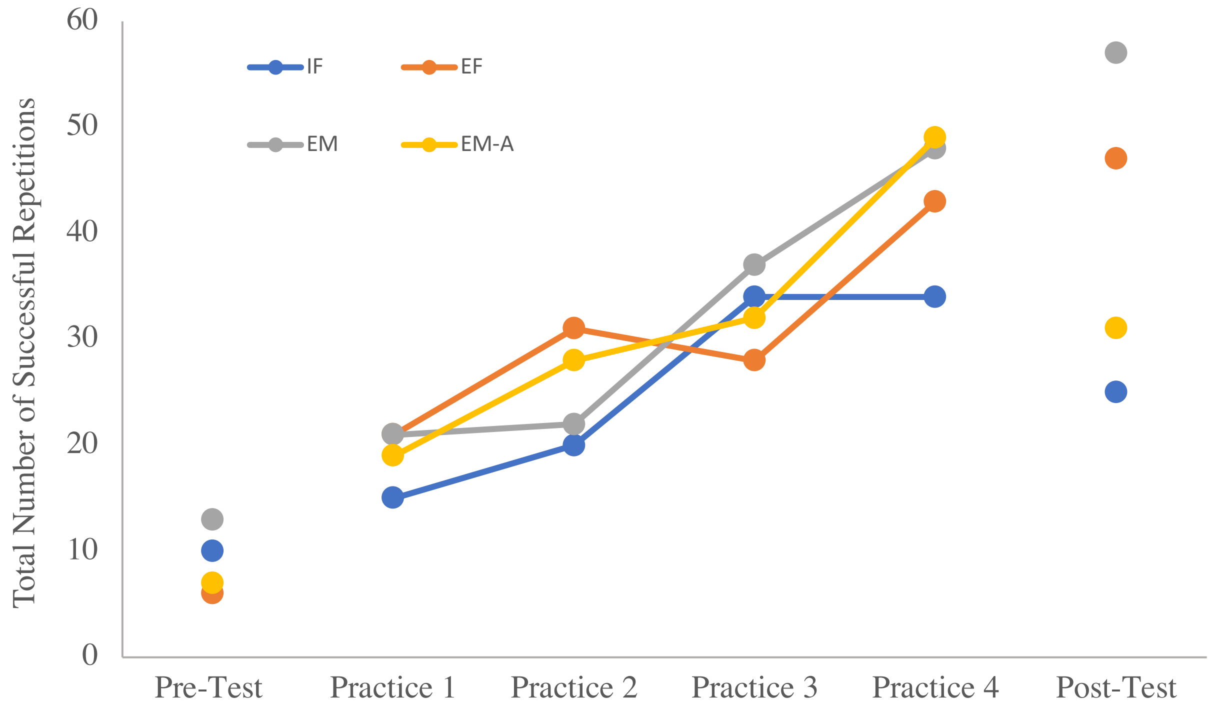

Figure 2. Total number of successful repetitions completed in the pre-assessment, practice sessions, and learning assessment for each group.

Appendix U

Tables

Table 1. Examples of reported foci within each content category.

Content category	Example	Number of reported cues		
		1st half	2nd half	Full practice
Object Manipulation				
Speed & Timing Cues	"arms fast on the side swing" "Slow it down until the last jump."	59	66	125
Movement Quality Cues	"I'm going to try to pull my left arm back more and come through." "big cross"	48	72	120
Foundational				
Height	"jump high" "I just need to think about getting more power, getting up higher."	30	21	51
Body position	"keeping my knees up, my body facing straight forward" "making sure my feet are positioned right slightly in front of the left, hips a little bit to the side"	36	36	72
Outcome	"I want to catch this handle. That's what I'm thinking right now." "Okay, just get the TS."	7	11	18
General performance	"Go! Stop thinking. Just go." "Try it for the last time and just go all out."	8	26	34

Table 2. Number of times participants in the EM-A group selected each type of focus cue during each practice session.

Participant ID	Speed/Timing Cue 1	Speed/Timing Cue 2	Speed/Timing Cue 3	Speed/Timing Cue 4	Movement Quality Cue 1	Movement Quality Cue 2	Movement Quality Cue 3	Body Position Cue 1	Body Position Cue 2	Height Cue 1	**Number of Cues Used**
					Practice 1						
501	1	1	1	2	1	1	1	2	3	2	**10**
502	0	3	n/a	1	2	0	3	3	3	0	**6**
503	2	3	0	1	3	0	2	2	7	5	**8**
504	1	2	0	2	0	0	0	0	6	4	**5**
505	2	1	1	0	0	4	6	1	0	0	**6**
508	0	7	0	0	8	0	0	0	1	5	**4**
509	0	2	1	1	1	1	3	n/a	3	3	**8**
510	2	0	0	4	1	0	1	0	0	7	**5**
511	0	0	15	0	0	0	0	0	0	0	**1**
512	3	3	0	0	3	0	0	3	0	3	**5**
514	0	5	0	0	0	0	0	5	0	5	**3**
515	1	2	1	2	2	1	1	2	1	2	**10**
					Practice 2						
501	2	1	2	1	1	1	1	2	2	2	**10**
502	0	0	n/a	3	0	3	4	2	3	0	**5**
503	3	2	1	1	0	2	2	3	6	2	**9**
504	2	3	0	2	0	0	0	0	5	3	**5**
505	0	0	0	10	0	1	2	1	1	0	**5**
508	4	3	0	0	13	0	0	5	2	3	**6**
509	0	2	0	4	3	0	3	n/a	2	1	**6**
510	0	5	0	1	1	0	3	0	1	4	**6**
511	0	0	0	0	0	15	0	0	0	0	**1**
512	0	0	3	3	0	3	3	0	3	0	**5**
514	0	0	0	0	5	0	0	0	5	5	**3**
515	1	2	2	1	2	1	1	2	2	1	**10**
					Practice 3						
501	1	2	2	1	1	1	1	2	2	2	**10**
502	3	3	n/a	0	0	3	0	2	2	2	**6**

Table 2 Continued.

503	2	5	0	2	1	1	3	3	5	2	**9**
504	2	2	0	5	0	0	0	0	4	2	**5**
505	0	0	0	6	0	1	2	0	6	0	**4**
508	0	3	0	0	6	0	2	1	2	2	**6**
509	5	2	0	0	0	4	0	n/a	3	1	**5**
510	0	6	0	1	2	0	4	0	1	3	**6**
511	0	3	3	3	3	3	0	0	0	0	**5**
512	3	3	0	0	3	0	0	3	0	3	**5**
514	5	0	0	0	0	0	0	0	5	5	**3**
515	2	1	1	2	1	1	2	2	1	2	**10**
Practice 4											
501	1	1	2	1	2	1	1	2	2	2	**10**
502	4	5	n/a	0	0	3	3	0	0	1	**5**
503	1	5	0	1	1	1	2	3	4	3	**9**
504	0	6	0	5	0	0	3	0	0	1	**4**
505	0	0	0	6	0	1	4	0	4	0	**4**
508	7	0	0	0	3	0	0	0	2	3	**4**
509	1	3	1	0	0	1	2	n/a	3	3	**7**
510	1	4	1	0	0	0	6	0	2	3	**6**
511	0	0	0	0	4	0	0	11	0	0	**2**
512	0	0	3	3	0	3	3	0	3	0	**5**
514	0	0	0	0	0	0	0	5	5	5	**3**
515	3	2	1	2	1	1	1	2	1	1	**10**

"N/a" indicates that this cue type was not represented on the participant's list of choices.

Table 3. Number of participants in each group who indicated each response range for the focus cue adherence survey item.

Group	0-20%	21-40%	41-60%	61-80%	81-100%
			Practice 1		
IF	0	0	3	2	7
EF	0	1	2	7	2
EM	0	0	1	3	8
EM-A	0	1	2	6	3
			Practice 2		
IF	0	1	1	2	8
EF	0	1	2	4	5
EM	0	0	0	6	6
EM-A	0	0	3	4	5
			Practice 3		
IF	0	0	1	2	9
EF*	0	1	2	3	5
EM	0	0	2	2	8
EM-A	0	0	2	5	5
			Practice 4		
IF	0	0	1	4	7
EF*	0	0	2	3	6
EM*	0	0	1	3	7
EM-A	0	0	2	3	7

**Indicates missing data for this group.*
Survey item: "During what percent of repetitions do you feel that you were able to focus on the given cues during today's practice?"

Table 4. Number of participants in each group who selected each response option for focus cue helpfulness.

Group	Very Unhelpful	Somewhat Unhelpful	Neither Helpful nor Unhelpful	Somewhat Helpful	Very Helpful
IF	0	0	0	7	5
EF	0	0	0	7*	5
EM	0	0	1	5	6
EM-A	0	0	1**	4	7

**One participant indicated that the cue was between "somewhat helpful" and "very helpful."*
***One participant indicated that the cues were between "neither helpful nor unhelpful" and "somewhat helpful."*
Interview question: "How helpful did you feel that the focus cue(s) given during the study was/were for learning the skill?"

VITA

Kaylee Couvillion Woodard grew up in Baton Rouge, Louisiana. She attended Parkview Baptist School where she was introduced to the world of competitive jump rope. After high school she attended Louisiana State University and graduated with a bachelor's degree in Kinesiology. During college, Kaylee continued to compete in jump rope at the international level. She also performed professionally with Cirque du Soleil, Cirque Dreams, and others. Kaylee went on to complete her master's degree in Exercise Science at the University of South Florida in 2016. In 2020, she will receive her Doctor of Philosophy degree in Kinesiology and Sport Studies with a specialization in Sport Psychology and Motor Behavior.