The effects of consistency and inconsistency between attentional focus and task objective in learning a golf putting task

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DEDICATION

To my mom, dad, and my grandmother Lily

Abstract

Converging evidence has demonstrated learning advantages when an individual is instructed to focus their attention externally. However, many of the motor tasks utilized in past research had clear external objectives (i.e., putting accuracy), creating a compatible relationship between an external focus of attention (i.e., outcome) and an external task objective (i.e., putting accuracy). The present study examined whether or not the consistency of instructions and task objective would differentially impact the acquisition of a golf putting task. Participants performed a putting task in a control condition or in one of four experimental conditions resulting from the factorial interaction of task instructions (internal or external) and task objective (internal or external). The retention and transfer data revealed that participants who received an external task objective demonstrated superior outcome scores. Participants who received technique information paired with outcome information demonstrated superior technique scores.

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1.0 Review of Literature

1.1 Motor Learning and Attentional Focus

Throughout a lifetime humans are continually executing motor skills that permit us to function optimally in daily life (Kantak & Winstein, 2012). Humans are born with certain motor skills, with maturation and experience these skills are refined to a complete form (Schmidt & Wrisberg, 2004). With age, novel motor skills (e.g., driving a car) are gained and previously learned skills are improved (Voelcker-Rehage, 2008).

Motor development and motor learning are two distinct fields of inquiry, but in spite of their differences, they interact and affect one another. Motor development is defined as changes in motor behaviour across a lifespan due to sequential age related processes (Schmidt & Lee, 2011; Voeckler-Rehage, 2008). Maturation/aging would be a factor that leads to developmental changes in movement. Motor learning is defined as a change in internal processes resulting from physical practice that leads to a relatively permanent change in the ability to perform a motor task (e.g., learning a volleyball jump serve as a result of practice) (Schmidt & Lee, 2011). Practice is considered one of the most important variables in motor skill acquisition, since the learner tends to become a more skilled performer (Kantak & Winstein, 2012). However, motor learning cannot be directly measured given that it involves complex internal cognitive and neural processes; thus, it has to be inferred by examining changes in motor performance (Kantak & Winstein, 2012; Schmidt & Lee, 2011).

Motor performance can be defined as an observable voluntary motor action, which is temporary in nature and is affected by levels of motivation, fatigue and/or arousal (Schmidt & Wrisberg, 2004). Motor performance can be measured by changes in reaction time, accuracy, or performance kinematics. Since motor learning cannot be directly measured it must be inferred by the measurement of motor performance during a retention test, when temporary practice effects on motor performance dissipate (Kantak & Winstein, 2012). A retention test determines how well a motor skill is learned after a period of time elapses following practice (Magill, 2011). Typically, an experimental session will include two retention tests: an immediate and a delayed. An immediate retention test varies from 10 seconds to a couple of hours after the last trial in the acquisition session, to assess any initial differences due to any experimental manipulations (Kantak & Winstein, 2012). A delayed retention test occurs at least 24 hours following the last acquisition trial, where consolidation occurs (Kantak & Winstein, 2012; Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002).

During the acquisition phase of motor learning an encoding phase occurs, resulting in the formation of a motor memory (Kantak & Winstein, 2012; Walker et al., 2002). Encoding is an “online” process that allows task related information to be processed, and connections between goals, movement, and movement outcome to be generated (Kantak & Winstein, 2012). Once the pre-defined practice period is over, a process called consolidation occurs. Consolidation is an “off-line” process that continues to strengthen motor memories in the absence of physical practice (Kantak & Winstein, 2012). This process not only continues immediately after physical practice but continues during a period of sleep (Kantak & Winstein, 2012; Walker et al., 2002). Therefore, it is essential to infer learning after 24 hours when motor memory consolidation has occurred (Kantak & Winstein, 2012; Walker et al., 2002). The following example demonstrates how learning is measured through the means of a retention test. An individual is learning how to perform a basketball jump shot, and the goal is to achieve the highest score by achieving as many points possible. If the individual gets the basketball into the target, they will receive one point, if they miss they will receive zero points. After ten practice shots, the performer earned six points, however after the 24 hour delayed retention session the performer earned nine points. This improvement in motor performance indicates that the process of consolidation occurred and learning of the motor skill is suggested.

Researchers have identified numerous practice variables that influence the acquisition of motor skills (e.g., organization of practice, augmented feedback frequency schedules, observational learning). An additional variable that has been investigated intensively is where an individual should focus their attention during the execution of a motor skill (Wulf, 2007a; Schmidt & Lee, 2011). In fact, converging evidence has demonstrated that where we allocate our attentional resources largely impacts how well we perform and learn a particular motor skill (Wulf, 2007b). Researchers have specifically examined the effects of instructing a performer to induce an external focus of attention or an internal focus of attention (Wulf, 2007a). Wulf, Höβ, and Prinz (1998) defined an external focus of attention as one that is directed towards the effects of movement on the environment (e.g., focusing on the centre of the dart board), whereas an internal focus of attention is directed towards the body's production of movement (e.g., focusing on their arm movements, while throwing the dart). Attentional focus has been investigated in numerous motor skills including a ski-simulator task (Wulf et al., 1998), golf (Wulf, Lauterbach, & Toole, 1999; Perkins-Ceccato, Passmore, & Lee, 2003), basketball (Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002), dart throwing (Marchant, Clough, & Crawshaw, 2007), tennis (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000), baseball (Castaneda & Gray, 2007), bicep curls (Vance, Wulf, Töllner, McNevin, & Mercer, 2004), running (Baden, Warwick-Evans, & Lakomy, 2004; Schücker, Hagemann, Strauss, & Völker, 2009), swimming (Stoate & Wulf, 2011) and various balance tasks (McNevin, Shea, & Wulf, 2003; Totsika & Wulf, 2003; Wulf & McNevin, 2003; Wulf, McNevin, & Shea, 2001a).

James (1890) described attention with characteristics such as focalization, concentration and consciousness. Humans have a limited attentional capacity and therefore can only process a limited amount of information at any moment (Schmidt & Wrisberg, 2004). Attention is also described as serial; we first pay attention to one aspect in the environment, and then proceed to focus our attention to another aspect (Schmidt & Wrisberg, 2004). For example, an athlete will allocate their attention to various situations such as attending to an external sensory event (opponents movement), an internal sensory event (sensations of fatigue), or even internal cognitive operations (planning strategic play) (Schmidt & Wrisberg, 2004). Since humans have a limited attentional capacity, it is imperative that the learner's attention is directed to the most relevant source of information (Schmidt & Wrisberg, 2004). The proper allocation of attention can lead to optimal performance outcomes such as, increased accuracy (Al-Abood et al., 2002; Wulf & Su, 2007), increased vertical (Wulf, Zachary, Granados, & Dufek, 2007b) and horizontal (Porter, Ostrowski, Nolan, & Wu, 2010b) jump distances, learning (Marchant et al., 2007; Wulf et al., 1998) and reduced muscle activity (Vance et al., 2004; Zachry, Wulf, Mercer, & Bezodis, 2005).

As an individual gains more experience in a certain motor skill, less attention is directed towards the required movements. Fitts and Posner (1967) proposed three stages of learning that tends to occur in a sequential process. First, the learner begins in the cognitive stage, where movements tend to be inefficient and inconsistent (Wulf, 2007a). At this point in time movements are controlled consciously, and learners tend to direct their attention to the step-by-step motor requirements (e.g., arm mechanics while performing a golf chip shot) (Fitts & Posner, 1967; Wulf, 2007a). As the learner progresses to the associative stage as a function of practice, movements tend to become more consistent, fluid, and economical (Wulf, 2007a). During this phase, certain aspects of the movements are controlled consciously and other aspects automatically, allowing the learner to direct more of their attention to other characteristics of the skill (e.g., focusing on club motion when performing a golf chip shot) (Wulf, 2007a). As the learner becomes more experienced they progress to the autonomous stage, where movements become automatic and attention is no longer needed during skill execution (Wulf, 2007a). For experts, it has been known that focusing attention to their movements can actually disrupt performance of these automatic skills (Beilock, Carr, MacMahon, & Starkes, 2002; Bliss, 1892-1983; Castaneda & Gray, 2007; Schmidt, 1988; Schneider & Fisk, 1983; Wulf, 2007a; Wulf, 2008).

During the early stages of the learning process, it is common that the learner is provided with instructions before or during practice regarding the correct movement patterns to ensure that a knowledge base is built (Poolton, Maxwell, Masters, & Raab, 2006). For example, when learning a push pass in soccer, the learner will be instructed to use the inside of their foot, along the arch of the dominant foot, and to keep their upper body bent slightly forward while striking the ball. These body-related instructions are common when teaching motor skills, and have been assumed as the most effective method by coaches (Porter, Wu, & Partridge, 2010c; Wulf et al., 1998). However, developing an explicit knowledge base during learning, by focusing the learner's attention to movement patterns has shown to actually disrupt performance, and therefore negatively impacts skill acquisition (Poolton et al., 2006; Wulf et al., 1998; Wulf & Weigelt, 1997). The results from recent research suggest that a performer's attentional focus should be directed towards the movement outcome. For example, when learning a basketball free throw, focusing on the rim of the net (i.e., external focus) will optimize performance and learning compared to focusing on arm movements during the release of the basketball (i.e., internal focus) (Marchant et al., 2007).

Singer, Lidor, and Cauraugh (1993) first investigated the effects of directing attention to body movements in the learning of a novel motor skill. Singer and colleagues (1993) suggested that for a learner to achieve a level of automaticity (similar to an expert), instructions that direct their attention away from their body movements should be adopted. To investigate this hypothesis, the experimenters had participants engage in an overhand ball throwing task using different learning strategies. The conscious "awareness" condition was instructed to consciously attend to various aspects of their movement (e.g., feeling of the movement). The "nonawareness" learning strategy condition was instructed to not consciously attend to their movement patterns and instructed to focus on one situational cue that is not related to their movement coordination (e.g., center of the target). Lastly, the Five-Step Approach group was instructed to follow sequential steps which included: readying, imaging, focusing, executing, and evaluating. This approach was to include certain aspects of both "awareness" and "nonawareness" components. Results revealed that the "nonawareness" condition and the Five-Step Approach condition had higher performance outcomes than those who were in the “awareness” condition. These results suggest that it is possible for a beginner to use an expert’s attentional focus during the execution of a motor skill. The results of this initial study challenged the traditional approaches of coaching (e.g., focus on movement mechanics), leading to believe that perhaps instructing a learner to be aware of what they are doing during skill execution may not be the best method to optimize learning. However, the need for additional empirical evidence was still needed to further explore this effect.

1.2 External vs. Internal Focus of Attention

1.2.1 First Experimental Evidence

Wulf et al. (1998) further explored attentional focus by designing a two part study that compared instructions that induced attention either away (i.e., external focus of attention) or towards the execution of movement (i.e., internal focus of attention). In the first experiment, Wulf and colleagues (1998), had participants learn the movements required on a ski-simulator task. The goal was to produce quick oscillatory movements with large amplitudes. Participants were either instructed to focus on their feet (internal condition), or to the outer wheels of the platform located directly under the participant’s feet (external condition), or were not given any instructions at all (control). Therefore, each condition had only subtle differences in attentional focus instructions.

Results revealed that individuals who focused externally had greater performance outcomes (greater amplitude) in both acquisition and retention, compared to both the control and the internally focused condition. Individuals in the internal focus of attention condition performed significantly inferior during acquisition compared to the control condition. However, during retention there were no significant differences between the internally focused condition and the control condition. This study was the first to provide empirical evidence demonstrating the learning advantages of an external focus of attention.

To further identify the generalizability of these findings, Wulf and her colleagues (1998, Experiment 2) used different attentional focus instructions with a different motor skill. Participants were required to balance on a stabilometer where the maximum deviation was 15 degrees in the participant's left and right direction. Participants were informed that the goal of the task was to keep the platform as horizontal as possible for each 90s trial. Participants performed this task either focusing on keeping their feet horizontal (internal), or keeping the two red markers that were located directly in front of their feet horizontal (external). Therefore, differences in attentional focus instructions between each condition were minimal. Similar to the first experiment, instructing the learner to focus their attention externally led to superior performance as indicated by root mean square error (RMSE) during retention when compared to participants focusing internally. However, there were no between group differences during acquisition. The investigators noted that a potential reason why no differences were found between conditions in acquisition were due to task demands. The first experiment utilized a ski-simulator task where the individual had to learn how to move the apparatus, in comparison with the second experiment where the individual performed a relatively innate balancing skill. Overall, this study exemplified that even subtle differences in an individual's attentional focus during movement execution can lead to superior performance and learning effects. The next logical step was to test this effect in different populations and various motor skills.

1.2.2 Generalizability of an External Focus of Attention Advantage

Wulf et al. (1998) demonstrated the effectiveness of instructing a learner to induce an external focus of attention in a laboratory setting. Since then, these benefits have been continuously observed in varying balance tasks (e.g., balancing on a stabilometer) (McNevin, Shea, & Wulf, 2003; Wulf et al., 1998; Wulf et al., 2003; Wulf & McNevin, 2003; Wulf et al., 2001a). Additional empirical evidence was needed to generalize these learning benefits to a more practical setting.

Totsika and Wulf (2003) used a dynamic balance task to determine if benefits associated with an external focus of attention would persist during transfer tests. Numerous studies examining the effects of attentional focus have incorporated retention tests (Maddox, Wulf, & Wright, 1999; Wulf et al., 1998; Wulf et al., 1999; Wulf et al., 2001a; Wulf et al., 2002; Wulf & Su, 2007; Zentgraf & Munzert, 2009) to infer how an individual's focus of attention affected motor skill acquisition. Totsika and Wulf (2003) stated that transfer tests are required to determine whether the advantages provided by an external focus of attention can transfer to novel variations of the practiced task. If the benefits do not transfer to a novel situation, then perhaps adopting an external focus of attention is specific to the practiced task. The investigators required participants to ride a Pedalo for a total of seven meters at their "own pace", either focusing on pushing with their feet (internal focus) or focusing on pushing the platforms (external focus). The investigators measured the time it took for the participant to complete the seven meters. Participants who were instructed to induce an external focus of attention were significantly faster than the participants instructed to induce an internal focus of attention. The following day, participants performed three different transfer tests without attentional focus instructions. The first transfer test was to ride the Pedalo forwards as fast as possible to provide the performer with the pressure of time. The second was to ride the Pedalo backwards as fast as possible to determine if the benefits generalized to a novel situation. Lastly, the third test was to ride the Pedalo forwards as fast as possible, while counting backwards to ensure the performer does not adopt either an internal or external focus. The secondary task created an additional attentional load, subsequently assessing the automaticity of the primary task. The external focus of attention condition exhibited faster movement times than the internal condition in all three transfer tests, suggesting the effects were relatively permanent and transferable to other novel variations of the practiced task.

To further determine the robustness of an external focus of attention advantage, Wulf et al. (1999) extended this body of research to a sport skill. Novice golfers were required to hit balls towards a circular target which had a radius of 45 cm. Four concentric circles were placed around the target for a quick and accurate scoring system. If the performer landed the golf ball onto the target five points were recorded. If the ball landed in the next concentric circle four points were recorded and so forth. If the ball landed outside all concentric circles zero points were given. While performing this task, performers were instructed to either focus on the motion of the club (external condition) or focus on the swing motion of their arms (internal condition). The first day consisted of 80 acquisition trials in blocks of ten, and the second day consisted of 30 retention trials, in blocks of ten. Similar to Wulf et al. (1998), the investigators found that during acquisition, individuals in the external condition were significantly more accurate (as indicated by higher scores) throughout all blocks in acquisition than the internal condition. More importantly, these benefits were not only temporary, but during the delayed retention test the external condition was significantly more accurate than the internal condition. While this study confirmed performance and learning advantages by instructions inducing an external focus of attention for a complex sport skill, comparison to a control group was not utilized.

Therefore, Wulf and Su (2007, Experiment 1), replicated the Wulf et al. (1999) golf study by adding a control condition. This control condition received the same instructions regarding the basic technique of a golf pitch shot; however they did not receive attentional focus instructions. Wulf and Su (2007) concluded that individuals in the internal and external focus of attention conditions had similar results to the respective conditions in the Wulf et al. (1999) experiment. Participants who focused on an external cue were significantly more accurate in retention than both the internal and control conditions. Interestingly, the internal and control condition had similar performances during both acquisition and retention, replicating the results of other studies utilizing a control group (Landers, Wulf, Wallmann, & Guadagnoli, 2005; Porter, Nolan, Ostrowski, & Wulf, 2010c; Wulf & McNevin, 2003; Wulf et al., 2003, Experiment 2). Overall, this large body of evidence suggests that instructing a learner to focus internally is similar to receiving no attentional focus instructions, yet focusing externally can enhance performance and learning (Wulf, 2007a).

The learning advantages of an external focus of attention in learning sport skills are generally viewed as robust. In addition to the benefits observed in various golf studies (Bell & Hardy, 2009; Wulf et al., 1999; Wulf et al., 2000; Wulf & Su, 2007), these advantages have also been observed in basketball (Al-Abood et al., 2002; Zachry et al., 2005), dart throwing (Marchant et al., 2007), soccer (Wulf, Wächter, & Wortmann, 2003), and tennis (Maddox et al., 1999). Adopting an external focus of attention can also facilitate faster swim times (Freudenheim, Wulf, Madureira, Pasetto, & Correa, 2010) as well as enhance an individual’s running economy (Schücker et al., 2009). These benefits have also been demonstrated in both males and females (Wulf et al., 2003). Since a majority of research has investigated the effects of attentional focus in sports skills, Wulf et al. (2007b) and Porter et al. (2010b), wanted to further explore these effects in learning to produce goal directed muscular force tasks.

Wulf et al. (2007b) and Porter et al. (2010b) were interested in determining if similar advantages would persist in a skill that can be assumed to be well learned. Wulf et al. (2007c) utilized a within-participant design, where participants were required to perform a vertical jump. A Vertec instrument which consisted of plastic rungs spaced 1.3 cm apart, was used to determine maximum vertical jump-and-reach height. Participants were instructed that the goal of the task was to jump and reach the highest possible plastic rung with the tips of their fingers. Participants were required to perform 5 trials under each attentional focus condition: internal (focus on the tips of their fingers), external (focus on the plastic rungs) and lastly a control condition where no attentional focus instructions were given. Wulf et al. (2007b) concluded that individuals instructed to induce an external focus of attention jumped significantly higher than focusing internally or without any attentional focus instructions. Were these advantages due to the participant producing increased vertical forces or did their body movements change in mid-air (e.g., greater shoulder extension) allowing them to reach higher? Therefore, Wulf and colleagues (2007b, Experiment 2) replicated the first experiment, with a few variations. In addition to measuring height, the investigators recorded center of mass (COM) displacement. For example, if the COM was higher for an individual focusing externally, it can be assumed that the individual produced greater vertical forces. Wulf and colleagues (2007b, Experiment 2), concluded that when an individual focused externally, a higher COM displacement resulted. The authors suggested that an increase in muscular coordination and an increase in motor unit recruitment efficiency is perhaps the factor contributing to why an external focus was advantageous.

Porter et al. (2010b) also had participants perform a maximum force production task, however this task required participants to jump in the horizontal direction. The investigators utilized a between-participant design, with participants focusing externally (focus on jumping past the start line) or internally (focus on extending your knees). The investigators found that the external condition jumped significantly further than the internal condition. Studies investigated by Porter et al. (2010b) and Wulf et al. (2007b) provided further empirical evidence for the robustness of an external focus of attention advantage.

Porter et al. (2010a) extended this study to determine if the benefits of an external focus of attention persist for motor tasks that require complex whole body movements. Participants were required to perform an agility “L” test, which consisted of two 5 meter sections consisting of running and turning components. A within-participant design was used and investigators instructed the participants to focus on reaching the pylons as quick as possible and to focus on pushing off the ground with maximal forces (external focus of attention). The internal instructions were to focus on rapidly moving their legs and planting their foot firmly while turning. Participants performed a control condition (no attentional focus instructions) prior to performing the counterbalanced internal and external conditions. Porter et al. (2010a) concluded that participants who focused externally had significantly faster movement times, compared to focusing internally or not having any attentional focus instructions.

Lohse and Sherwood (2011) were interested in extending this body of research to an isometric task that required participants to engage in a wall-sit posture. This task was performed in three different attentional focus conditions. All participants performed the task with an internal focus of attention. The internal focus of attention instructions was to focus on keeping their thighs as parallel as possible to the floor and to limit any movement. Due to the nature of the task, half of the participants performed the task with an external-associative focus, and the other half performed the task with an external-dissociative focus. The external-associative focus instructions were to draw imaginary lines from their knee to hip and to keep these lines parallel to the floor. The external-dissociative focus instructions were to focus on creating imaginary lines between the pylons directly in front of the participant, and to focus on keeping these lines parallel to the floor. Focusing externally (either associative or dissociative) resulted in a significantly longer (improved) time to failure compared to an internal focus, an external focus also had lower perceived exertion scores. Overall, this study demonstrated that focusing internally may increase perceptions of fatigue, while focusing externally can distract the performer from focusing on internal sensations of fatigue.

Freedman, Maas, Caligiuri, Wulf, and Robin (2007) further generalized the advantages of an external focus of attention by exploring the effects of attentional focus on the oral-facial system with an impulse force control task. Participants were asked to generate a series of rapid pressure exertions using their tongue and hand onto two separate bulbs. The goal was to reach 20% of their maximum strength in a single exertion. Participants were randomly assigned to either an internal focus or external focus of attention condition. The internal focus group was instructed to focus on their tongue/hand, whereas the external group was instructed to focus on the bulb. The authors concluded that adopting an external focus of attention resulted in greater accuracy (indexed by absolute error), and less variability (indexed by variable error) for both the hand and the tongue.

Duke, Cash, and Allen (2011) examined the effects of attentional focus in performing a 13-note keyboard passage. Participants were required to direct their attention to either an internal cue (focusing on their fingers) or an external cue (focusing either on the keys, piano hammers or the sound produced). Participants played the sequence under all four attentional conditions, with the order being counterbalanced. Participants were significantly more accurate when focusing on one of the distal external foci (e.g., piano hammers, sound produced) compared to the proximal external focus (keys) or the internal focus (fingers). Overall, this study concluded that utilizing motor skills with an auditory component benefits from inducing an external focus of attention, consistent with the existing literature on sport and force production motor skills.

Converging evidence has demonstrated the overwhelming benefits of an external focus of attention in both novice and expert performers, however these benefits do not persist when performance is at an optimal level such as in world-class athletes. Wulf (2008) hypothesized that the most effective method would be to provide the expert with no attentional instructions (control condition) so that the expert can adopt the focus they would typically use during performance (‘normal’ focus). This was not consistent in the results found in the study by Wulf and Su (2007) who concluded that an expert’s optimal focus is an external cue (e.g., focusing on the club motion) rather than their ‘normal’ focus (control condition). Wulf (2008) was therefore interested in determining if similar results would be observed in world-class acrobats from Cirque du Soleil. Participants balanced on an inflated rubber disk, while adopting an external focus of attention (minimize the movement of the disk) an internal focus of attention (minimize movements of the feet) and a control condition (stand still). When experts were given the instructions to stand still (control), participants performed significantly better compared to when they focused internally and externally, as indicated by mean power frequency (MPF). Essentially, world class movement experts experienced superior performance when adopting a ‘normal’ focus. Wulf (2008) suggested that perhaps an internal focus of attention or an external focus of attention was not found to be advantageous for the balance experts since each foci encouraged them to consciously attend to a lower control level (e.g., focusing on the disk), ultimately disrupting automatic control mechanisms.

The majority of studies exploring the effects of attentional focus have used young adults between the ages of 20-30 years (Wulf, 2007a). Thorn (2006) and Emanuel, Jarus, and Bart (2008) investigated if these benefits would persist in children. Thorn (2006) had children aged 9-12 use a Biodex Balance System (a moveable platform that measures postural sway). Participants either focused on their feet (internal) or the platform (external). Children in the external condition had less postural sway than the internal condition. Interestingly, Emanuel et al. (2008) found conflicting results when children aged 8.4 to 9.8 years participated in a dart throwing task. The goal of the task was to throw the dart into the center of the dart board either focusing on limb movements (internal) or the target (external). There were no significant differences in accuracy (indicated by mean radial error) between conditions and interestingly, the internal condition was significantly more accurate during the transfer phase. The authors suggested that a potential reason why an external focus of attention was not found to be more effective in children is due to their inferior implicit learning (Emanuel et al., 2008). Therefore, children may need to learn the step-by-step movement requirements to improve their motor learning (Emanuel et al., 2008).

In addition to young adults, an external focus of attention has demonstrated benefits in older adults (e.g., increased time in balance) (Chiviacowsky, Wulf, & Wally, 2010), individuals with movement disorders such as Parkinson's disease (e.g., greater stability) (Launders et al., 2005) and stroke patients (e.g., increased performance of daily tasks) (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002).

Overall, research has demonstrated robust support for an external focus of attention advantage compared to an internal focus of attention, or no attentional focus instructions (control condition). Wulf et al. (1998) were the first to demonstrate external focus of attention benefits in a laboratory setting, and since then has been observed in a variety of complex sport skills, such as golf (Wulf et al., 1999; Wulf & Su, 2007). Evidence provided in this section has also demonstrated the generalizability of this advantage in an agility task (Porter et al., 2010a), maximum force production tasks (Wulf et al., 2007b; Porter et al., 2010b), music performance (Duke et al., 2011), oral-facial skills (Freedman et al., 2007) and has also been observed to lower perceptions of fatigue, resulting in longer time to failure in a wall-sit posture (Lohse & Sherwood, 2011).

Totsika and Wulf (2003) have also determined that these benefits persist not only during acquisition (Wulf et al., 1999, Experiment 1; Wulf et al., 1999) and retention (Wulf et al., 1998; Wulf et al., 1999; Wulf & Su, 2007) but also during multiple transfer tests (Totsika & Wulf, 2003). However, an external focus of attention advantage did not persist in world-class athletes, since their performance is already at an optimal level, indicating a limit to this external focus of attention advantage.

1.3 External Focus of Attention or Distraction from an Internal Focus of Attention?

The focusing strategy used by Singer in the Five-Step Approach was to ensure the performer directed their focus away from movement execution (internal focus) (Singer, 1988; Singer et al., 1993). More recently, research has demonstrated the benefits of focusing on the movement effect (i.e., external focus of attention), compared to the movement itself (i.e., internal focus of attention). However, it remained unclear whether an external focus was generating performance and learning benefits, or was it the fact that an internal focus was *not* adopted (Wulf & McNevin, 2003). If distracting the learner from an internal focus was the leading contributor to these performance benefits, then there would be no differences between focusing on the movement effects and distracting the learner from their movement production (Wulf & McNevin, 2003; Wulf, 2007a).

Wulf and McNevin (2003) investigated the influence of a non-task related focus while balancing on a stability platform. Participants in the internal focus of attention condition focused on keeping their feet horizontal, the external focus of attention condition focused on the markers on the platform, the control condition did not receive instructions, and lastly the shadowing condition repeated a story. Participants in the external condition performed superior in retention compared to the other groups as indicated by RMSE. The results showed that distracting the learner from an internal cue by focusing on a non-relevant task cue (e.g., repeating a story) was not an effective method in acquiring a new motor skill. In contrast, performance and learning was enhanced when the individual focused on the movement effect (i.e., external focus of attention). In addition to Wulf and McNevin (2003), other researchers found similar advantages when focusing on the movement effect (i.e., external focus of attention) compared to an irrelevant focus (e.g., tone counting) (Castaneda & Gray, 2007), and instructions related to the antecedent of the action (e.g., focusing on the tennis ball coming from their opponent) (Wulf et al., 2000).

In summary, the results from the aforementioned research suggests that performance and learning benefits are attributed to instructing the learner to induce an external focus of attention (e.g., focus on the platform markers) compared to an internal focus (e.g., focus on feet while balancing on the stabilometer) or a non-task related focus (e.g., shadowing a story while balancing on the stabilometer) (Wulf & McNevin, 2003).

1.4 Distance Effects

For certain motor skills, an individual can focus on multiple external foci. For example a soccer player may focus on the ball or the target during skill execution (Wulf, 2007a). Multiple studies have found that increasing the distance of an external focus of attention will increase the learning advantage (Bell & Hardy, 2009; McNevin et al., 2003; Wulf, 2007a; Wulf et al., 2000).

McNevin et al. (2001) examined the effects of increasing the distance between the body and the movement effect. Participants were required to balance on a stability platform while focusing with either an external or internal focus of attention. The unique aspect of this study was the addition of different variations of an external focus of attention. Participants in the near group (proximal external focus) focused on the markers directly in front of their feet, whereas the far-inside group (distal external focus) and the far-outside group (distal external focus) focused on markers that were 23 cm and 26 cm from their toes. Lastly, the internal focus group was instructed to focus on their feet, similar to previous experiments. During retention, participants who adopted a more distal focus of attention (far-inside and far-outside) had better performance outcomes as indexed by RMSE, than participants who were instructed to focus on the markers that were proximal to their body (near). Interestingly, Park, Shea, McNevin, and Wulf (2000) instructed participants to focus on markers that were attached to two one meter rods, which were extended in front of the stabilometer, directly in front of the participant's feet. The researchers concluded that increasing the distance of a task related external cue to an even a greater distance continued to improve performance and learning outcomes.

Bell and Hardy (2009) also examined the effectiveness of different variations of an external focus of attention, however this experiment had expert golfers perform a golf chip shot. The investigators hypothesized that a distal external focus would produce greater accuracy outcomes than both an internal focus and a proximal external focus. A target (e.g., center of a dartboard) (Castaneda & Gray, 2007; Wulf et al., 2000) and the ball's flight after making impact (e.g., the flight of a golf ball after being hit by a golf club) (Perkins-Ceccatto et al., 2003; Zachry et al., 2005) have both been described in previous literature as a distal external focus. A proximal external focus has been described as a focus closer to the body, such as focusing on the motion of the club (Wulf & Su, 2007), or focusing on the markers directly in front of the participant's feet (Wulf et al., 1998, Experiment 2). Bell and Hardy (2009) had participants focus on either the motion of their arms (internal condition), on the clubface during the participant's swing (proximal external), or on the ball's flight after making impact (distal external). Participants in the distal external condition were significantly more accurate in comparison to the internal and proximal external conditions. Bell and Hardy (2009) suggested that a distal external focus is more advantageous by allowing performance to be mediated by automatic control processes, since it may be difficult for the learner to differentiate between an internal focus of attention and a proximal external focus. Overall, this study extended the results of the McNevin et al. (2001) study by demonstrating the effectiveness of increasing the distance of the movement effect. However, this study used expert golfers, and the McNevin et al. (2001) used a motor skill that is relatively innate. Therefore, the next logical step was to investigate if these benefits of a distal external focus would persist in novices learning a complex skill.

Wulf et al. (2000, Experiment 2), addressed this concern by differentiating the effects of focusing on a proximal and distal external focus. Novice golfers were required to hit golf balls as close to the target as possible, while focusing either on an external proximal focus (club movements) or an external distal focus (ball's trajectory and the intended target). Interestingly, participants that focused on the proximal cue were significantly more accurate, during both acquisition and retention. The difference in results between this experiment and the studies investigated by Bell and Hardy (2009) and McNevin et al. (2001) is potentially due to the level of expertise. A participant who is learning a complex skill may need to be instructed to focus on a technique related cue (i.e., club) to learn the basic mechanics of the swing, whereas an advanced golfer may already have the skill automatic (Bell & Hardy, 2009).

Overall, research has demonstrated that focusing on an external cue, compared to an internal cue has learning benefits, even if there are only subtle differences between the two foci. However, increasing the distance of an external focus of attention from proximal (e.g., focusing on the club movements) to distal (e.g., focusing on the target) will continue to increase this learning effect. An internal (e.g., focus on feet) and a proximal external focus (e.g., focus on markers located directly in front of the participant's feet) may be harder to distinguish for the performer, and therefore will consciously intervene automatic control processes, whereas a distal external focus will promote natural automatic control processes. This effect may be limited to the individual's level of expertise.

1.5 Task Complexity

Wulf and Shea (2002) defined a simple skill as having one degree of freedom and able to master in a single session, whereas a complex skill has more than one degree of freedom, and cannot be mastered in a single session. Wulf, Töllner, and Shea (2007) hypothesized that there would be no additional advantage when focusing on an external cue if the task was simple. If the task is relatively complex advantages in performance and learning are observed, as outlined by previous research (Duke et al., 2011; Freudenhein et al., 2010; Marchant et al., 2007; Porter et al., 2010b; Wulf et al., 1999). Wulf et al. (2007) designed a two part study to investigate the effects of attentional focus on both a simple and complex task. The first experiment required participants to balance on a flat metal surface or on a foam mat, both being placed on a force platform.

Balancing on the foam mat was considered to be slightly more challenging than the metal surface since it was more difficult to maintain a stable posture. Participants performed each task while focusing internally (focus on their feet), externally (focus on the rectangles they are standing on) and without any attentional instructions. No differences were found between groups when participants stood on the metal surface (indicated by RMSE), however the external condition performed superior compared to the control condition when standing on the foam surface. The investigators concluded that the two balancing tasks in the current experiment were too simple to observe performance and learning advantages associated with an external focus of attention, compared to an internal focus of attention. Perhaps, using conditions that are more challenging will demonstrate an external focus of attention advantage.

Wulf et al. (2007) designed a second experiment that utilized a task with less stability (standing on an inflated rubber disk) and an unstable support surface (standing on an inflated rubber disk using two legs or one leg), resulting in a more challenging task. This task was performed while focusing on limiting the motion of the disk (external), focusing on limiting the motion of their feet (internal) and with no attentional instructions. Wulf et al. (2007a) concluded that focusing externally in both tasks (balancing on one leg or two legs) resulted in less postural sway (greater stability), compared to focusing internally, or not receiving any attentional focus instructions.

In summary, advantages associated with an external focus of attention depend on the difficultly of the task. If the task is relatively simple such as the ones utilized in Experiment 1, and the learner has few errors (e.g., less postural sway) the learner will not feel the need to intervene motor control processes (Wulf, 2007a; Wulf et al., 2007a).

However, if the task is relatively complex such as the ones utilized in Experiment 2, adopting an internal focus of attention will encourage the learner to pay attention to their movements, consequently hindering their automatic control processes (Wulf, 2007a; Wulf et al., 2007a).

1.6 Constrained Action Hypothesis

Advantages associated with an external focus of attention are explained through the constrained action hypothesis (McNevin et al., 2000; McNevin et al., 2001; Wulf et al., 2001a; Wulf et al., 2001b, Wulf & Prinz, 2001). According to this hypothesis, an individual that directs their attention internally (i.e., movement coordination) will consciously intervene automatic processes that would typically regulate their movements (Wulf, 2007a). In comparison, when an individual focuses externally, unconscious processes regulate their movements (Wulf, 2007a; Wulf & Prinz, 2001). Numerous studies have provided support for the constrained action hypothesis; relating to increased frequency of movements adjustments (McNevin et al., 2003; Wulf et al., 2001b), ability to dual task (Wulf et al., 2001a), and efficient muscular activity (Marchant, Greig, & Scott, 2009; Vance et al., 2004).

Wulf et al. (2001, Experiment 2) and McNevin et al. (2003) were both interested in explaining why these advantages occur. Similar to the Wulf et al. (1998) study, Wulf et al. (2001, Experiment 1) had participants balance on a stability platform focusing either on their feet (internal) or the markers on the board (external). McNevin et al. (2003) used the same task with the exception of adding three conditions: near (proximal external focus), far-outside (distal external focus), and far-inside (distal external focus). In addition to measuring RMSE, both studies also used Fast Fourier Transformations to analyze frequency characteristics of balance movements. High frequency adjustments indicate faster adjustments to perturbations, indicating that the movement is being controlled at an automatic level. Lower frequency adjustments would indicate larger movement corrections, indicating a conscious intervention of automatic processes (Wulf & Prinz, 2001; Wulf, 2007a). Wulf et al. (2001b) concluded that when participants focused on the board (external focus) they had smaller RMSE values and higher response frequencies (mean power frequency), compared to when participants focused on their feet (internal focus). McNevin et al. (2003) concluded that both the far-outside and far-inside conditions had higher frequency adjustments during retention than both the internal and near conditions.

Furthermore, Wulf et al. (2001a) utilized a dual-task procedure where participants balanced on a stability platform (primary task) while engaging in a probe reaction time task (secondary task). Wulf et al. (2001a) hypothesized that less attention would be required to balance on the stabilometer, therefore, more attention could be dedicated to the secondary probe reaction time task, when an external focus is adopted. The goal was to keep the stability platform horizontal while focusing either on keeping their feet horizontal (internal) or keeping the board horizontal (external). While balancing, participants were also required to perform a secondary task, which consisted of pressing a button when an auditory stimulus was presented. In line with the constrained action hypothesis, participants who focused on keeping the board horizontal (external condition) had faster probe reaction times during retention. Consequently, the internal condition required an increase in attentional demands while performing the primary task, as indicated by slower probe reaction times. The investigators concluded that an external focus of attention compared to an internal focus of attention requires less attention.

Vance et al. (2004) were interested in understanding performance differences between an internal and external focus of attention at the neuromuscular level. Participants performed a biceps curl with a bar that had a mass equivalent to 50% of their maximum strength. The investigators used electromyography (EMG) analysis to measure muscle activity. All participants performed two sets of 10 repetitions while either focusing on their arms (internal) or the bar (external). EMG electrodes were placed on both the biceps and the triceps to analyse contraction patterns between both agonist and antagonist muscles. Results revealed that during the initial repetitions, an external focus reduced neuromuscular activity in both the biceps and the triceps compared to an internal focus. Since each condition involved participants lifting the same amount of weight, it can be concluded that an external focus increases motor unit recruitment efficiency and promotes effective coordination between muscles, as indicated by lower EMG activity in both biceps and triceps. In addition, lower EMG activity was also found when adopting an external focus of attention compared to a control condition (Marchant et al., 2006), and performing a sports task, specifically a basketball free throw (Zachry et al., 2005).

1.7 Attentional Focus and Task Objective

Several studies have failed to replicate the benefits of an external focus of attention in novice performers (Beilock et al., 2002; Castaneda & Gray, 2007; Denny, 2010; Ford, Hodges, & Williams, 2005; Perkins-Ceccato et al., 2003). Certain researchers have argued that less skilled individuals should direct their attention to the step-by-step execution of the skill, so that the individual can learn the proper technique (Beilock et al., 2002; Castaneda & Gray, 2007; Ford et al., 2005; Perkins-Ceccato et al., 2003). Once the proper technique has been learned and the skill becomes more automatic the individual can then direct their attention to an external focus. According to the deautomization-of-skills hypothesis novices do not perform a skill automatically, and therefore automatic control processes cannot be disrupted (Beilock et al., 2002; Ford et al., 2005).

Lawrence, Gottwald, Hardy, and Khan (2011) also failed at replicating the previously shown benefits of an external focus of attention. The vast majority of research in this area has demonstrated the benefits of an external focus of attention in tasks that have had an external objective (e.g., accuracy). However, few studies have examined these effects in tasks that have an internal objective (e.g., technique). Therefore, Lawrence et al. (2011) examined attentional focus effects in a gymnastics floor routine, with a pre-defined movement technique as the dependant measure. Participants were required to watch a model perform a gymnastics routine, and then were asked to replicate this routine as accurately as possible. Individuals in the external condition were instructed to focus on their movement pathways (e.g., exert an even pressure onto the support surface) whereas individuals in the internal condition were instructed to focus on various aspects related to their movement coordination (e.g., focusing on keeping their arms straight, level with their shoulders). Professional judges assessed their performance (technique) by providing a score between zero and ten (a score of ten indicated no errors). No significant differences were found in the retention and transfer tests; suggesting an external focus of attention was not found to be beneficial based on the fact the task objective was internal (e.g., movement technique).

Jackson and Holmes (2011) were interested in determining whether the advantages associated with an external focus of attention were in fact due to the benefit of consistency often observed in previous research between attentional focus and an external task objective. For example, Wulf et al. (1998) found that an external focus of attention (focus on keeping the board horizontal) to be more advantageous, however the task objective itself was to keep the board horizontal, ultimately creating a consistent relationship. Moreover, Porter et al. (2010c) also found an external focus of attention (reaching the pylons as quick as possible) to be more advantageous in performing an agility "L" test however, once again the task objective was to reach the pylons as quick as possible (external objective). Wulf et al. (2007c) found an external focus of attention (focus on reaching the highest plastic rung) to be more advantageous, however the goal of the task was to reach the highest plastic rung (external objective), once again suggesting a consistent relationship between attentional focus and task objective. Thus, an internal focus of attention would not be expected to be more effective for learning based on the inconsistent relationship between an internal focus of attention and an external task objective.

To further explore the issue, Jackson and Holmes (2011) examined the effects of consistency and inconsistency between focus of attention instructions and task objective in a dynamic balancing task. Participants balanced on a stability platform that had a maximum deviation of 15 degrees in the participant's left and right direction. Participants were randomly assigned to a condition with either a consistent or inconsistent relationship between perceived task objective and attentional focus. The following conditions were: internal/feet, internal/board, external/feet, and external/board. The internal groups were instructed to focus on keeping their feet level, whereas the external groups were instructed to keep the board level. The addition of two task objectives was the unique aspect of this study. Participants in the board groups were instructed that the only variable being measured was the board angle. However, participants in the feet groups were instructed that the only variable being measured was how level their feet were. Participants were informed that the movements of their feet would be analyzed using a motion analysis. A video camera was placed at shoe-level and neon markers were placed on the back of their shoes. However, the only variable being measured was the angle of the stability platform. Results revealed that during acquisition, participants in the consistent conditions performed significantly better (indexed by RMSE) than participants in the inconsistent conditions.

Over the past decade, numerous studies have demonstrated the overwhelming benefits of an external focus of attention. However, recent research by Jackson and Holmes (2011) suggests that these benefits may be due to the consistency between an external focus of attention and an external task objective. Further investigation is needed to understand the effects of consistency and inconsistency between attentional focus and task objective in learning various motor skills.

In summary, the advantages associated with an external focus of attention compared to an internal focus of attention or no attentional instructions, are generally viewed as robust. These advantages have been observed in a variety of motor skills such as balance tasks (McNevin et al., 2003; Wulf et al., 1998; Wulf et al., 2003), sports tasks (Al-Abood et al., 2002; Marchant et al., 2007; Maddox et al., 1999), maximum force production tasks (Porter et al., 2010b; Wulf et al., 2007b), an agility task (Porter et al., 2010a), a keyboard task (Duke et al., 2011) and an oral-facial task (Freedman et al., 2007). These benefits have also been observed in different populations such as older adults (Chiviacowsky et al., 2010), Parkinson's patients (Landers et al., 2005), and stroke patients (Fasoli et al., 2002). Previous studies have also demonstrated the advantage of an external focus of attention compared to instructing the learner to induce a non-task relevant focus (Wulf & McNevin, 2003) or the antecedent of the action (Wulf et al., 2000). In addition, performance and learning benefits are enhanced by increasing the distance of an external focus of attention (Bell & Hardy, 2009; McNevin et al., 2001) and when the task is more challenging (Wulf et al., 2007a). These advantages have been explained through the constrained action hypothesis (Marchant et al., 2006; McNevin et al., 2003; Wulf et al., 2001a). However, few studies have focused on determining if an external focus of attention advantage would still persist if the task objective is technique related (internal objective). Is there a limit to an external focus of attention advantage, when the task objective is internal? Future studies are required to further investigate these effects.

2.0 Introduction

Research examining the importance of attentional focus during the acquisition of motor skills has been a prevalent focus of motor learning research (Duke et al., 2011; Jackson & Holmes, 2011; Lawrence et al., 2011; Marchant et al., 2007; Perkins-Ceccato et al., 2003; Shea & Wulf, 1999; Toksika & Wulf, 2003; Vance et al., 2004; Wulf & Weigelt, 1997; Wulf et al., 1998; Wulf et al., 2001a; Wulf, 2008; Zachry et al., 2005). A large body of research has suggested that where we allocate our attentional resources largely impacts how well we perform and learn a particular motor skill (for reviews see Wulf & Prinz, 2001; Wulf, 2007b).

Traditionally, when practicing new motor skills teachers, practitioners, or coaches often believe it is necessary to instruct the learner to focus on their movement patterns. For example, when learning a soccer instep kick, a coach may give the learner instructions regarding the correct position of the foot and to ensure they have their upper body bent slightly forward. However, over the past decade there has been converging evidence suggesting that focusing on the body's production of movement (internal focus) may not be as effective as focusing on the effects of movement on the environment (external focus) (Wulf, 2007a). Wulf and her colleagues (1998) were the first among many researchers to demonstrate the advantages of instructing the performer to induce an external focus of attention, relative to an internal focus of attention during two separate experiments, examining the acquisition of a ski-simulator and a stabilometer task. Subsequent studies have demonstrated the effectiveness of an external focus of attention in a variety of motor skills which include, basketball (Al-Abood et al., 2002; Zachry et al., 2005), dart throwing (Marchant et al., 2007), golf (Wulf et al., 1999; Wulf & Su, 2007), vertical jumping (Wulf et al., 2007), bicep curls (Vance et al., 2004), and running (Baden et al., 2004; Schücker et al., 2009). In addition, this benefit has also been observed in older adults (Chiviacowsky et al., 2010), individuals with movement disorders such as Parkinson's disease (Launders et al., 2005) and stroke patients (Fasoli et al., 2002). This effect has also been found in both novice (Marchant et al., 2007; Wulf et al., 1999) and expert performers (Wulf & Su, 2007, Experiment 2). However, the advantages of an external focus did not extend to top-level performers on a balance task (Wulf, 2008).

To explain the advantages of an external focus, McNevin and her colleagues (2001) proposed the constrained action hypothesis. According to this hypothesis, an individual who directs their attention towards the coordination components of their movement will disrupt the automatic control processes that regulate movement (Wulf, 2007a). However, focusing on the effects of the movement is suggested to induce an automatic mode of movement control (Wulf, 2007b). Multiple studies using fast Fourier transform (FFT) analysis discovered that focusing externally compared to internally demonstrated higher frequency-movements while balancing on a stability platform (McNevin & Shea, 2001; McNevin et al., 2003; Wulf et al., 2001a; Wulf et al., 2001b). In addition, Wulf et al. (2001a) utilized a (secondary) probe RT task while simultaneously balancing on a stability platform, to provide additional evidence for the constrained action hypothesis. If an external focus of attention allows movements to be controlled automatically, individuals who focused externally would require less attention to balance and therefore more attention could be directed to the secondary probe reaction time task (resulting in faster probe RTs). This indeed was found since participants in the external focus condition had faster probe reaction times compared to the internal focus condition. Lastly, instructing a performer to induce an external focus of attention also results in lower muscular activity as indicated by an EMG analysis, in tasks such as a biceps curl (Vance et al., 2004) and a basketball free throw (Zachry et al., 2005). This reduction in muscular activity is suggested to be from an increase in motor unit recruitment efficiency and effective muscular coordination (Vance et al., 2004; Zachry et al., 2005).

Despite the effectiveness of an external focus of attention demonstrated by numerous studies, other researchers have not been successful replicating these benefits (Beilock et al., 2002; Castaneda & Gray, 2007; Denny, 2010; Ford et al., 2005; Perkins-Ceccato et al., 2003). For example, Denny (2010) examined attentional focus in the learning of a jump float serve in volleyball (complex open skill) and found no significant differences between focusing on an internal cue (hand position on volleyball) and focusing on an external cue (flight path of ball). More recently, Lawrence and colleagues (2011) investigated the effects of adopting either an internal or external focus of attention in a form-based gymnastic task, where performance was measured by judging movement technique. There were no significant differences between the internal and external group, suggesting that there is no advantage of having a specific focus of attention in that particular task. Potentially, an external focus of attention was not found more advantageous because the objective itself was not external.

There is limited research determining if the benefits of an external focus of attention extend to tasks that have an internal objective. Jackson and Holmes (2011) argue that previous research has primarily observed the effects of attentional focus in tasks that had a primary external goal (Al-bood et al., 2002; Marchant et al., 2007;

Zachry et al., 2005; Wulf et al., 2000; Wulf & Su, 2007; Wulf et al, 2007b). For example, Marchant and colleagues (2007) had participants engage in a dart throwing task where the objective was to achieve a low score (bull's eye 0 points). Participants were instructed to concentrate on their movement coordination (internal focus) or the center of the dart board (external focus). The external focus of attention condition was significantly more accurate than the internal condition. However, Jackson and Holmes (2011) suggest this is due to the external focus of attention group having a compatible relationship with the task objective, compared to the internal condition that often has an incompatible relationship. Even tasks that are not sport skills such as balance, demonstrate this conflict between task objective and focus of attention (Jackson & Holmes, 2011). For example, Wulf et al. (1998), had participants balance on a stabilometer (external objective), while focusing on either their feet (internal focus of attention condition) or the board (external focus of attention). Participants were informed that the only variable being measured was how level they could keep the platform (known external objective). Results showed that the external group had higher learning outcomes compared to the internal group, however the internal group had an inconsistent relationship between task instructions and task objective. Perhaps, the consistent relationship between an external focus of attention and an external task objective often observed in previous studies, is the factor contributing to why an external focus of attention continually leads to superior performance and learning (Jackson & Holmes, 2011). The inconsistent relationship between an internal focus of attention and an external objective could explain why numerous studies have demonstrated less successful performances when inducing an internal focus. Therefore, the robust support for an external focus of attention is suggested to be attributed to the consistency between focus of attention and task objective (Jackson & Holmes, 2011). Ultimately, further research is required to determine the role of consistency in attentional focus with task objective.

2.1 Statement of the Research Problem

It is currently suggested that focusing externally while practicing a motor skill results in superior performance and learning (Al-Abood et al., 2002; Marchant et al., 2007; Schücker et al., 2009; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007). However, more recently Jackson and Holmes (2011) stated that these advantages may be due to consistency between an external focus of attention and an external task objective. To investigate this thought, Jackson and Holmes (2011) had participants balance on a stabilometer with either a consistent or inconsistent relationship between task objective and focus of attention. The results of this study found that participants who had a consistent relationship had greater performance outcomes than those with an inconsistent relationship during acquisition, however no differences in performance were found in retention. The investigators revealed that a potential reason why no differences were found in retention were due to the limited amount of acquisition trials.

The findings from Jackson and Holmes (2011) suggest that the role of attentional focus in motor learning is inconclusive. Thus, further studies are required to determine if the role of consistency between instructions and task objective have an influential role on the acquisition of motor skills. Based on Jackson and Holmes (2011), there is reason to believe that an internal focus of attention can be beneficial to novice learners if the known task objective is also internal. Therefore, manipulating the task objective to be consistent with the focus of attention could potentially be advantageous during the learning of motor skills (Jackson & Holmes, 2011). The results of this further inquiry would be instrumental in demonstrating to coaches or teachers, that not only should the attentional focus be considered when teaching a motor skill, but the perceived task objective as well (Jackson & Holmes, 2011). In summary, an important question needs to be addressed: is an external focus of attention the variable facilitating motor performance and learning, or are the learning benefits of an external focus of attention modulated by consistency of the motor task goal?

Therefore, the purpose of this thesis was to determine if a consistent relationship between focus of attention (i.e., internal or external) and the known task objective (i.e., internal or external) would have superior performance outcomes in a putting task in acquisition, retention, and transfer compared to an inconsistent relationship. A putting task was chosen given that there are known internal (adhering to various aspects of the proper technique) and external objectives (landing the ball as close as possible to the target hole), and has important practical implications.

2.2 Experimental Predictions

Based on previous literature, the following predictions were made:

1. Participants in the external/external objective consistent condition would have superior outcome scores than participants in the internal/internal objective consistent condition, the inconsistent conditions (internal/external objective, external/internal objective), and the control condition, in acquisition, retention, and transfer (Al-Abood et al., 2002; Marchant et al., 2007; Porter et al., 2010b; Schücker et al., 2009; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007).

2. Participants in the internal/internal objective consistent condition would have superior technique scores than participants in the external/external objective consistent condition, the inconsistent conditions (internal/external objective, external/internal objective), and the control condition, in acquisition, retention, and transfer (Jackson & Holmes, 2011).

3.0 Methods

3.1 Participants

Sixty novice golfers, 40 females and 20 males from Brock University (*M* age = 22.4, *SD* = 2.08) were recruited to participant in this study. An equal amount of females and males were across all experimental conditions. Participants were classified as inexperienced golfers using a similar criterion Roberts and Turnbuil (2010) used in their study examining lateral attentional biases in novices during a putting task. Participants were excluded if they received any formal golf training, and/or played five or more rounds of golf in their lifetime. Participants also self-proclaimed their dominant hand prior to the beginning of the study and only right handed individuals were allowed to participate. Participants were randomly assigned to one of five experimental conditions: internal/internal objective (*n* = 12), internal/external objective (*n* = 12), external/internal objective (*n* = 12), external/external objective (*n* = 12), control (n = 12). At the beginning of acquisition, all participants were informed of the experimental protocol and provided informed consent that had been approved by the Brock University Research Ethics Board. Participants were naïve to the purposes of this study.

3.2 Task and Apparatus

During acquisition, retention, and transfer sessions, participants performed a golf-putting task on an artificial turf in the Motor Skills Acquisition Laboratory at Brock University (see Appendix A). During the experimental phases, participants stood upon a 0.203 m high wood platform supporting the green indoor/outdoor putting carpet. The dimensions of the putting area were 3.66 m (length) by 1.23 m (wide). The golf ball was placed in the same starting position every trial, by marking the turf with a 6 cm x 6 cm taped square (Lee, Ishikura, Kegel, Gonzalez, & Passmore, 2008). The ball was placed by the participant anywhere in this square. The putting distance from the starting position to the standardized golf hole of 10.8 cm (Dail & Christine, 2004) was a total of 2.74 m (Hung, 2002; Jackson & Willson, 1998). This distance was consistent during acquisition, retention, and transfer. Movements were recorded by Dartfish software technology (Dartfish, Canada) through a digital video camera (Canon VIXIA HV40) located at a distance of 2.74 m to the right and 2.74 m to the front of the participant. All participants were provided with a conventional putter that was 88.5 cm in length (Breed & Steinbreder, 2011). Regulation solid white golf balls (Top Flite XL 7000, China) were used by all participants in both the acquisition and retention sessions (McGlynn, Jones, & Kerwin, 1990). Yellow foam practice balls were used in the transfer session (Hank Haney, Canada).

The experiment required participants to putt a golf ball a distance of 2.74 m into the target hole. To ensure quick and accurate measurements of putting distance, a point scoring system was adopted from Jackson and Willson (2008) (see Appendix B). Scoring accuracy of the putt was based on five concentric circles with the standardized hole of 10.8 cm being the centre of the five circles. To maintain consistency, the distance from the edge of the standardized golf hole to the next scoring zone was 10.8 cm in each direction. Each additional scoring zone was 10.8 cm from the edge of the previous scoring zone (see Appendix B). Five points were awarded if the ball landed in the target (zone 1). Four points were awarded if the ball landed in the second concentric circle (zone 2). Three points were awarded if the ball landed in the third concentric circle (zone 3), two points were awarded if the ball landed in the fourth concentric circle (zone 4). If the ball landed in the fifth concentric circle, one point was awarded (zone 5) (Jackson & Willson, 2008). Lastly, zero points were awarded if the ball finished outside all of the concentric circles (zone 6), similar to the point system used by Wulf et al. (1999). If the participant missed the ball during execution, no score was recorded, and the participant was required to re-take the putt. If the ball was in contact with two zones, points were awarded to the zone that had a larger percentage of the ball's surface area. Following each trial, the experimenter recorded the ball's location. This was inspected visually by the experimenter, however if a situation arose where it was difficult to determine which scoring zone the ball ended in, the participant was required to redo the trial at the end of that specific block. The scoring zone was also evenly divided into four sections by two perpendicular lines. The experimenter recorded the quadrant the ball landed in after each putt to help analyze the consistency of shots. The ball could land in one of the four quadrants: top left (TL), bottom left (BL), top right (TR), bottom right (BR). The ball could also land outside of the concentric circles (OUT) or in the target hole (IN).

Technique was also measured through the means of a point scoring system, in total five aspects were scored. Participants received one point if one of the five aspects were adhered to. Zero points were awarded if the aspect was not adhered to. If every aspect of the skill was adhered to in a single trial, the participant was awarded a total of five points. To achieve five points, the participant must have adhered to the following: feet lined up with each shoulder, elbows slightly flexed with no rotation in the forearms or lower body, knees lined up with one another and slightly flexed and lastly, hips were required to be bent over (trunk slightly flexed) (see Appendix C). All trials were recorded for analysis and the experimenter rated movement form by watching videos using

Dartfish software technology (Dartfish, Canada). The videos were randomized by a second experimenter, so that it was not known which conditions participants were assigned to.

Similar to the study investigated by Perkins-Ceccato et al. (2003), participants were not provided knowledge of results (KR). KR refers to extrinsic information provided to the learner regarding how accurate their motor response was in relation to the environmental goal (Schmidt & Wrisberg, 2004). For the present study, providing the learner with their outcome score (e.g., a score from 0-5 points) would have been considered as KR. KR was not provided since it has been acknowledged to be an influential factor leading to trial to trial variability (Perkins-Ceccato et al., 2003). In addition, this helped ensure that participants in the internal objective conditions were primarily focused on learning technique. Participants were also not given knowledge of performance (KP) during the acquisition, retention, or transfer sessions. KP provides the learner with information regarding the quality of their movements. (Schmidt & Lee, 2011; Schmidt & Wrisberg, 2004). All participants received basic instructions regarding technique prior to acquisition, however any movement corrections during trials were not given.

Participants were required to wear Portable Liquid Crystal Apparatus for Tachistoscopic Occlusion (PLATO) spectacles (Translucent Technologies, Inc., Toronto, ONT, Canada), to occlude the putting distance outcome. Participants had full vision during preparation and execution of stroke up until ball contact was made, when the experimenter manually switched the goggles to a translucent state where complete vision was occluded (Perkins-Ceccato et al., 2003). The translucent state allowed the participant's eyes to stay illuminated so that once the goggles were re-opened their eyes did not have to re-adapt to the environment. The approximate duration from switching the goggles from a transparent to a translucent state was 3ms (Translucent Technologies, Inc). The purpose of vision occlusion was that any changes in both motor performance and learning were due to attentional focus and task objective instructions and not KR. Participants were also required to wear Mastercraft Standard Earmuffs to eliminate any auditory feedback.

The goal of the motor task was to sink the ball into the target hole while adhering to the instructed technique. However, participants had different task objectives depending on which condition they were assigned to. Participants were assigned to a group with an objective that was either consistent or inconsistent with their focus of attention instructions. For example, participants in the internal focus of attention groups either had an internal objective (consistent) or an external objective (inconsistent). Participants in the external focus of attention groups either had an external objective (consistent) or an internal objective (inconsistent). Participants that were assigned to the control condition were only informed of the overall experimental goal, attentional focus instructions or a task objective was not given.

The internal objective groups were instructed that their objective was to learn the instructed technique of the golf putt. Therefore, their goal was to demonstrate all aspects of the learned technique by adhering to a checklist during the preparation and execution of their stroke. This scoring protocol was only given to the internal objective conditions, and instructed that this was the only variable being measured.

The external objective groups were instructed that their objective was to land the golf ball as close to the target as possible, using the same outcome scoring method previously mentioned. This scoring protocol was only given to the external objective conditions, and were instructed that this was the only variable being measured. Therefore, the external objective conditions were naïve to the scoring protocol of the internal objective conditions, and the internal objective conditions were naïve to scoring protocol of the external objective conditions. During the immediate and delayed retention period, the experimental task was the same as during acquisition. During the transfer test, participants utilized a lighter foam practice golf ball to reach the target hole. Scoring protocols were explained once verbally and by means of a static display (36 cm x 36 cm computer screen), prior to engaging in the 60 acquisition trials.

3.3 Experimental Procedure

Upon arrival, participants engaged in ten practice trials to assess baseline measurements of initial performance (outcome and technique were recorded) without the use of PLATO spectacles. The only instruction given was to putt the golf ball into the target hole while adhering to their preferred technique. The purpose of this familiarization session was to allow the participant to become familiar with the apparatus. Once the experimenter collected baseline measurements, participants were then debriefed about the overall experimental goal, which was to putt the ball into the target hole while adhering to the instructed technique. After receiving information regarding the overall goal, participants received information concerning the proper technique of a golf shot. These instructions focused on stance, stroke, and grip. The proper stance taught was to have their hips square and bent forward until their eyes were directly over the ball

(Wright, 2010). Knees were instructed to be slightly and equally flexed, and to ensure that there was no rotation in the lower body (Pelz, 2000). Participants were also instructed to have a wide stance, so that their feet were lined up with the center of each shoulder. This stance has been demonstrated by professionals to ensure a stable and effective stroke (Pelz, 2000). A narrow stance and fully extended joints would have demonstrated instability and create the tendency for the participant to rotate their lower body (Wright, 2010). In regards to the upper body, participants were instructed to keep their shoulders square, and to ensure their elbows were slightly and equally flexed. Lastly, participants were asked to not rotate their forearms or generate power from their wrists and hands (Wright, 2010). The main power source should have been derived from the finesse of the swing, and the gentle swinging of the shoulders and arms (Pelz, 2000). Participants were also taught the pendulum stroke. Many golf professionals claim this stroke type to be the easiest and most effective (Pelz, 2000). Utilizing this stroke technique ensures that the larger muscle groups do not dictate how fast the ball rolls, which is a mistake commonly made in golf putting (Pelz, 2000). Participants were also instructed to imagine a triangle formation with their shoulders and arms. The tip of this triangle was where their hands gripped the putter, and the base of the triangle was each shoulder. Participants were then instructed to swing the club back and forth in a constant rhythmic motion (Wright, 2010). The reverse overlap grip, which tends to be the most commonly used among both novice and experts putters was then instructed (Stockton & Rudy, 2011). Participants were instructed to have their thumbs pointing downwards in the same direction, parallel to one another (Stockton & Rudy, 2011). All four fingers of the right hand were instructed to be placed on the shaft, with the left hand placed above, and the forefinger of the left hand was to overlap the fifth finger of the right hand (for a right-handed individual) (Stockton & Rudy, 2011). These instructions were provided on a 36 cm x 36 cm computer screen, and were read by the instructor.

Depending on the condition participants were assigned to (internal/internal objective (*n* = 12), internal/external objective (*n* = 12), external/external objective (*n* = 12), external/internal objective (*n* = 12), control (*n* = 12)) the investigator then explained focus of attention and task objective instructions both verbally and through the means of a static display. These instructions were presented in a series of slides using Microsoft PowerPoint. The slides were presented as long as the participant requested and any questions were answered. The control condition was not given any attentional focus instructions or was not given a task objective. They were only informed of the overall experimental goal, which was to putt the ball into the target hole while adhering to the instructed technique.

Within the internal focus of attention conditions, participants were instructed to concentrate on different aspects of the skill. In total there were five aspects participants focused on (see Appendix D). This information was provided on a 36 cm x 36 cm computer screen before each trial. Participants were instructed to focus on keeping a wide stance, having a slight bend in their elbows without forearm rotation and gently swinging from their shoulders (Pelz, 2000; Wright, 2010). Subsequently, participants were also instructed to focus on having their hips bent, keeping their knees slightly flexed, and not rotating their lower body (Pelz, 2000; Wright, 2010).

The external focus of attention conditions were instructed to focus primarily on the target. This information was also provided on a 36 cm x 36 cm computer screen before each trial. Similar to a study examining the effects of attentional focus in a dart throwing task investigated by Marchant et al. (2007), participants were instructed to focus on the center of the target, and on all concentric rings surrounding the target. Subsequently, they were instructed to re-focus on the target making it as large as possible, and once focused putt the ball into the target hole (see Appendix D).

In addition, participants were also informed of their task objective. Individuals in the internal objective (technique) conditions were instructed that their primary objective was to learn the technique of the putting motion previously explained, while adhering to the instructed attentional focus. The experimenter proceeded to discuss the technique scoring protocol, and informed participants that this was the only dependent variable being measured.

Participants in the external objective (outcome) conditions were informed that their primary objective of the task was to score as many points possible by sinking the golf ball into the target, while adhering to the instructed attentional focus instructions. This scoring system was identical to the scoring protocol previously mentioned. Participants were therefore informed of the different zones represented by the concentric circles around the target. Once all participants understood their attentional focus instructions and their task objective, two practice trials were completed with the PLATO spectacles, followed by 60 acquisition trials, in blocks of ten.

To ensure that the focus of attention instructions were adhered to, participants were reminded every fifth trial of what aspects they should be focusing on, similar to previous studies (Perkins-Ceccato et al., 2003; Taylor & Shaw, 2002). The focus of attention instructions were also placed on a computer monitor before each trial in the acquisition period. In addition, participants were required to complete an allocation of attention questionnaire (see Appendix F). All participants were asked to indicate where they allocated their attention while performing the task, to estimate the percentage they dedicated to the indicated aspect(s) and lastly rank their order of attention. This questionnaire was completed at the end of acquisition (after the 60^{th} trial).

To infer learning, participants engaged in both a retention (immediate and delayed) and transfer session. Following the 60 acquisition trials, participants had a no practice period prior to the ten trial immediate retention test. Approximately twenty-four hours after the last trial in the acquisition period, a delayed retention test consisting of 10 trials was performed. Following the delayed retention test, participants completed 10 transfer trials. During retention and transfer sessions participants were not given focus of attention reminders. See Appendix E for an overview of the experimental sessions.

Data collection occurred over two consecutive days. Changes in performance were assessed by calculating the mean score for outcome and technique, separately, for the ten six acquisition blocks. Performance was assessed in the retention period by averaging outcome and technique scores separately for the one block of 10 trials, during both the immediate and delayed retention periods. For the transfer period the means for both dependant variables were collapsed into one block of 10 trials.

3.4 Data Analysis

To determine if there were any statistical differences for the dependent variables (outcome and technique scores) between the experimental conditions and the control condition at pre-test, acquisition, retention (immediate and delayed), and transfer, separate 5 (practice condition: internal/internal objective, internal/external objective, external/internal objective, external/external objective, control) one-way analysis of variance (ANOVAs) were performed with repeated measures on blocks for the pre-test (1 block), acquisition (6 blocks), retention (2 blocks) and the transfer test (1 block).

To examine the interactive effects of consistency and inconsistency between attentional focus and task objective during the acquisition period, the data was analyzed in a separate 2 (focus of attention: internal, external) x 2 (task objective: internal, external) x 6 (blocks) analysis of variance (ANOVA) with repeated measures on the last factor. Performance in retention was analyzed using a separate 2 (focus of attention: internal, external) x 2 (task objective: internal, external) x 2 (retention test: immediate, delayed) ANOVA with repeated measures on the last factor. Performance in the transfer period was analyzed in a separate 2 (focus of attention: internal, external) x 2 (task objective: internal, external) ANOVA.

All statistical analyses were conducted using the commercially available software Statistica version 7.0 by StatSoft Inc. For all statistical analyses, $p \leq .05$ was used as the alpha level, and Tukey's honest significant difference post hoc analysis was used to analyze any statistically significant interactions. Partial eta squared (η^2) was used as a measure of effect size where appropriate.

4.0 Results

4.1 Outcome Scores

The block means for outcome scores for all experimental conditions for the acquisition, retention, and transfer period are displayed on the left side of Figure 1.

4.1.1 Pretest

There were no statistically significant differences between the experimental conditions at the pre-test, as determined by the one-way ANOVA, $F(4, 55) = 0.55$, $p = .70$.

4.1.2 Acquisition

The 5 (practice condition: internal/internal objective, internal/external objective, external/internal objective, external/external objective, control) x 6 (blocks) ANOVA with repeated measures on the last factor revealed a significant main effect for block, $F(3.76, 206.88) = 5.53$, $p < .001$, $\eta^2 = 0.09$. Mauchly's test of sphericity indicated that the assumption of sphericity was violated, therefore the degrees of freedom were adjusted using the Greenhouse-Geisser adjustment. The post hoc analysis indicated that block 1 was performed with lower outcome scores than blocks 5 and 6, and block 2 was performed with lower scores than block 5. The main effect for condition was not statistically significant, $F(4, 55) = 2.37$, $p = .06$, neither was the block x condition interaction, $F(16.7, 229.67) = 1.43$, $p = .11$.

The 2 (focus of attention: external, internal) x 2 (task objective: external, internal) x 6 (blocks) ANOVA with repeated measures on the last factor revealed a significant main effect for objective, $F(1, 44) = 9.57$, $p = .003$, $\eta^2 = 0.18$, with the external objective conditions ($M = 12.28$, $SE = 1.10$) demonstrating higher outcome scores than the internal objective conditions (*M* = 7.47, *SE* = 1.10). There was also a statistically significant main effect for block, $F(5, 220) = 6.71$, $p < .001$, $\eta^2 = 0.13$. The post hoc analysis indicated that block 1 was performed with lower outcome scores than block 5 and 6, and block 2 was also performed with lower outcome scores than blocks 5 and 6. The main effect for focus of attention, $F(1, 44) = 0.06$, $p = .81$ was not statistically significant. The focus of attention x objective interaction, $F(1,44) = .60$, $p = .44$; focus of attention x block interaction, $F(5, 220) = 1.15$, $p = .34$; objective x block interaction, $F(5, 220) = 1.93$, $p = .09$; and the focus of attention x objective x blocks interaction, $F(5, 220) = 1.01$, $p = .41$; were also not statistically significant.

4.1.3 Retention

The main effect for condition, $F(4, 55) = 2.25$, $p = .08$; retention test, $F(1, 55) = 0.27$, $p = .61$; and the condition x retention interaction, $F(4, 55) = 0.71$, $p = .59$, were not statistically significant, as revealed by the 5 (practice condition: internal/ internal objective, internal/ external objective, external/ internal objective, external/ external objective, control) x 2 (retention: immediate, delayed) ANOVA with repeated measures on the last factor.

A 2 (focus of attention: external, internal) x 2 (task objective: external, internal) x 2 (retention: immediate, delayed) ANOVA with repeated measures on the last factor revealed a significant main effect for objective, $F(1, 44) = 7.43$, $p = .009$, $\eta^2 = 0.14$ with the external objective conditions (*M* = 14.38, *SE* = 1.52) demonstrating higher outcome scores than the internal objective conditions (*M* = 8.52, *SE* = 1.52). The main effects for both focus of attention, $F(1, 44) = 0.03$, $p = .87$; and retention, $F(1, 44) = 0.54$, $p = .47$, were not statistically significant. The focus of attention x objective interaction, $F(1, 44) =$

1.87, p = .18; focus of attention x retention interaction, $F(1, 44)$ = .006, p = .94; objective x retention interaction, $F(1, 44)$ = 2.39, p = .13; and the focus of attention x objective x retention interaction, $F(1, 44)$ = 0.11, p = .74; were also not statistically significant.

4.1.4 Transfer

There were no statistically significant differences between the experimental conditions and the control condition, as determined by a one-way ANOVA, $F(4, 55)$ = 2.28, p = .07. The 2 (focus of attention: external, internal) x 2 (task objective: external, internal) ANOVA revealed a significant main effect for objective, $F(1, 44)$ = 7.83, p = .008, η^2 = 0.15, with the post-hoc analysis showing the external objective conditions (M = 13.00, SE = 1.41) demonstrating higher outcome scores than the internal objective conditions (M = 7.42, SE = 1.41). The main effect for focus of attention, $F(1, 44)$ = 0.39, p = .53, was not statistically significant, nor was the focus of attention x objective interaction, $F(1, 44)$ = 0.09, p = .77.

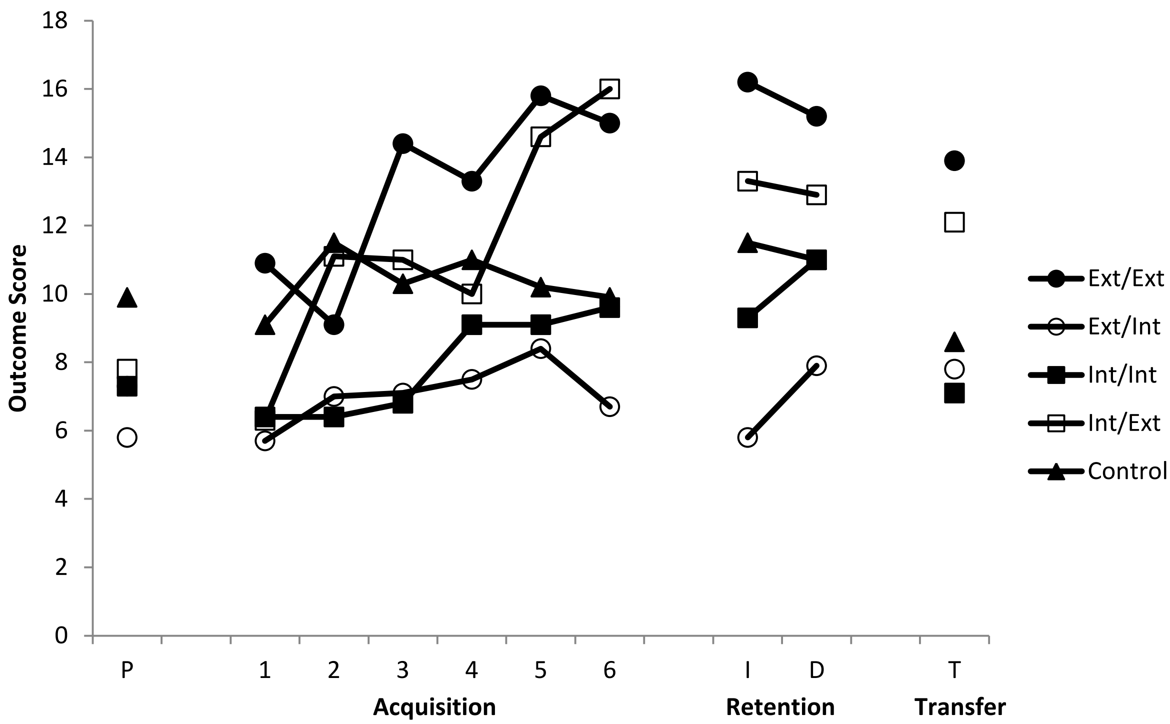

Figure 1. Outcome scores for all experimental conditions for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment.

4.2 Technique Scores

The block means for technique scores for all experimental conditions for the acquisition, retention, and transfer period are displayed on the left side of Figure 2.

4.2.1 Pretest

There were no statistically significant differences between the experimental conditions at the pre-test, as determined by the one-way ANOVA, $F(4, 55) = 0.83$, $p = .51$.

4.2.2 Acquisition

The 5 (practice condition: internal/ internal objective, internal/ external objective, external/ internal objective, external/ external objective, control) x 6 (blocks) ANOVA with repeated measures on the last factor revealed a significant main effect for block,

$F(3.76, 206.88) = 5.50$, $p < .001$, $\eta^2 = 0.09$. Mauchly's test of sphericity indicated that the assumption of sphericity was violated, therefore the degrees of freedom were adjusted using the Greenhouse-Geisser adjustment. The post hoc analysis indicated that block 1 was performed with lower scores than blocks 4, 5, and 6, and block 2 was performed with lower technique scores than block 6. The main effect for condition was also statistically significant, $F(4, 55) = 2.97$, $p = .027$, $\eta^2 = 0.18$. The post hoc analysis showed the external/external condition ($M = 26.38$, $SE = 1.60$) and the control condition ($M = 27.15$, $SE = 1.60$) having statistically lower technique scores than the external/internal condition ($M = 32.43$, $SE = 1.60$) and the internal/external condition ($M = 31.96$, $SE = 1.60$). The block x condition interaction, $F(15.05, 206.88) = 0.88$, $p = .61$, was not statistically significant.

The 2 (focus of attention: external, internal) x 2 (task objective: external, internal) x 6 (blocks) ANOVA with repeated measures on the last factor revealed a significant main effect for block, $F(3.55, 156.17) = 3.59$, $p = .01$, $\eta^2 = 0.08$. Mauchly's test of sphericity indicated that the assumption of sphericity was violated, therefore the degrees of freedom were adjusted using the Greenhouse-Geisser adjustment. The post hoc analysis indicated that block 1 was performed with lower scores than block 6. There was also a statistically significant focus x objective interaction, $F(1, 44) = 7.34$, $p = .009$, $\eta^2 = 0.14$. The post hoc analysis indicated that participants who had an external focus of attention with an external task objective ($M = 26.38$, $SE = 1.46$) had lower technique scores than participants who had an external focus of attention and an internal task objective ($M = 32.43$, $SE = 1.46$) and participants who had an internal focus of attention and an external task objective ($M = 31.96$, $SE = 1.46$) (see Appendix G for interaction plot). The main effect for focus of attention, $F(1, 44) = 1.22$, $p = .27$, and the main effect for objective, $F(1, 44) = 2.04$, $p = .16$, were not statistically significant. The focus of attention x block interaction, $F(3.55, 156.17) = 0.43$, $p = .82$; objective x block interaction, $F(3.55, 156.17) = 1.10$, $p = .36$; and the focus of attention x objective x blocks interaction, $F(3.55, 156.17) = 1.39$, $p = .23$; were also not statistically significant.

4.2.3 Retention

The 5 (practice condition: internal/ internal objective, internal/ external objective, external/ internal objective, external/ external objective, control) x 2 (retention: immediate, delayed) ANOVA with repeated measures on the last factor revealed a significant main effect for condition, $F(4, 55) = 4.31$, $p = .004$, $\eta^2 = 0.24$, with the external/external ($M = 26.1$, $SE = 1.49$) and control condition ($M = 26.83$, $SE = 1.49$) performing with lower technique scores than the external/internal condition ($M = 33.00$, $SE = 1.49$) and the internal/external condition ($M = 32.9$, $SE = 1.49$). The main effect for retention, $F(1, 55) = 0.47$, $p = .49$, and the condition x retention interaction, $F(4, 55) = 0.26$, $p = .90$, were not statistically significant.

The 2 (focus of attention: internal, external) x 2 (task objective: internal, external) x 2 (retention: immediate, delayed) ANOVA with repeated measures on the last factor revealed a statistically significant focus x objective interaction, $F(1, 44) = 10.63$, $p = .002$, $\eta^2 = 0.19$. The post hoc analysis revealed that participants who had an external focus of attention with an external task objective ($M = 26.70$, $SE = 1.44$) had lower technique scores than participants who had an external focus of attention and an internal task objective ($M = 33.00$, $SE = 1.44$) and participants who had an internal focus of attention and an external task objective ($M = 32.90$, $SE = 1.44$) (see Appendix H for interaction plot). The main effects for focus of attention, $F(1, 44) = 1.02$, $p = .32$; objective, $F(1, 44) = 1.20$, $p = .28$; and retention, $F(1, 44) = 0.11$, $p = .75$, were not statistically significant. The focus of attention x retention interaction, $F(1, 44) = .06$, $p = .81$; objective x retention interaction, $F(1, 44) = 0.42$, $p = .52$; and the focus of attention x objective x retention interaction, $F(1, 44) = 0.17$, $p = .69$; were also not statistically significant.

4.2.4 Transfer

A one-way ANOVA determined a significant main effect for condition, $F(4,55) = 4.09$, $p = .006$, $\eta^2 = 0.23$, with the external/external condition ($M = 25.58$, $SE = 1.53$) performing with lower technique scores than the external/internal condition ($M = 33.00$, $SE = 1.53$) and the internal/external condition ($M = 32.08$, $SE = 1.53$). There were no statistical differences between the experimental conditions and the control condition ($M = 27.50$, $SE = 1.53$).

The 2 (focus of objective: internal, external) x 2 (task objective: internal, external) ANOVA with repeated measure on the last factor showed a significant focus x objective interaction, $F(1, 44) = 11.81$, $p = .001$, $\eta^2 = 0.21$, and the post hoc analysis revealed that participants who had an external focus of attention with an external task objective ($M = 25.58$, $SE = 1.44$) had lower technique scores than participants who had an external focus of attention and an internal task objective ($M = 33.00$, $SE = 1.44$) and participants who had an internal focus of attention and an external task objective ($M = 32.08$, $SE = 1.44$) (see Appendix I for interaction plot). The main effect for focus of attention, $F(1, 44) = 1.14$, $p = 0.29$, was not statistically significant, neither was the main effect for objective, $F(1, 44) = 2.90$, $p = 0.95$.

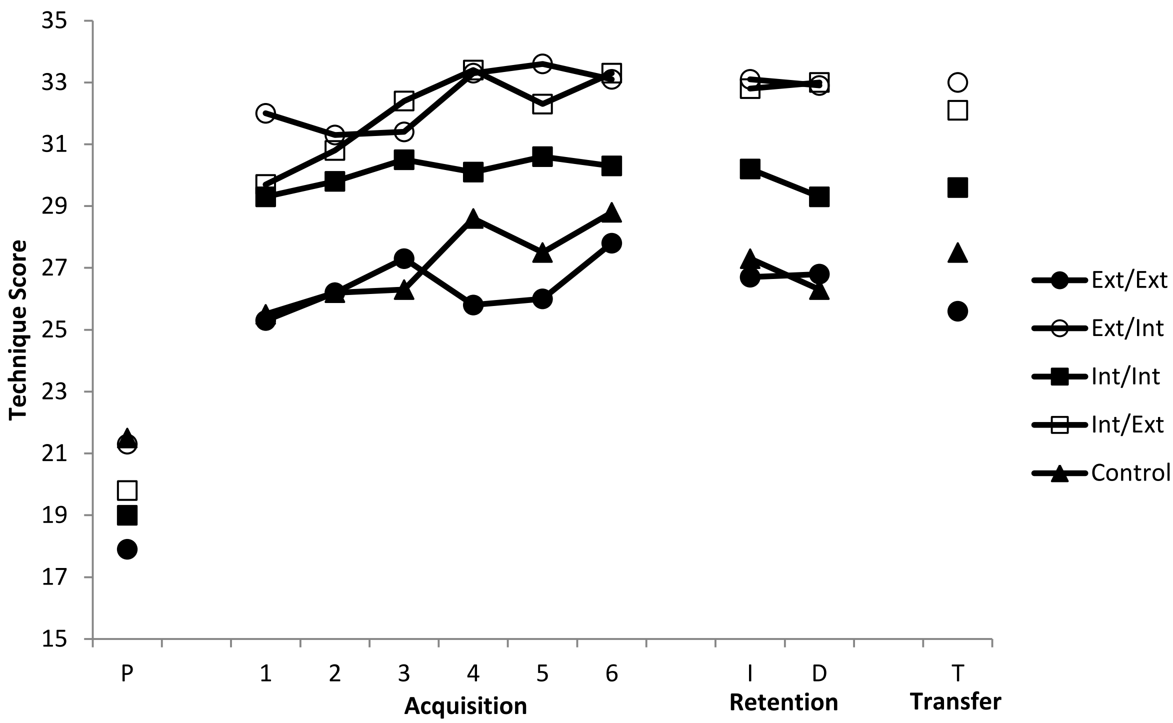

Figure 2. Technique scores for all experimental conditions for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment.

4.3 Allocation of Attention Questionnaire

The purpose of the allocation questionnaire was to determine whether participants adhered to the attentional focus instructions during the acquisition period. Participants were administered this questionnaire upon completion of the acquisition period (i.e., following their 60th acquisition trial). The results from this questionnaire are displayed in Table 1. Conditions that were instructed to focus externally (i.e., external/external objective, external/internal objective) self-reported focusing primarily on the target (40%). In comparison, the internal/internal objective and the internal/external objective condition dedicated a greater amount of attention to various aspects (i.e., grip and hips), with both conditions focusing more on shoulders/forearms (21% and 24%, respectively) and stance (23% and 19%, respectively). The control condition focused primarily on the target (55%).

Table 1

Self-reported allocation of attention questionnaire results for all conditions

Condition	***Target**	*** Rings**	**Stance**	**Grip**	**Shoulders/ Forearms**	**Hips**	**Knees**	**Lower Body**	**Other**
Ext/Ext	40%	18%	10%	18%	5%	1%	5%	2%	2%
Ext/Int	40%	9%	11%	18%	8%	3%	5%	4%	2%
Int/Int	17%	0%	23%	15%	21%	3%	14%	8%	0%
Int/Ext	11%	5%	19%	17%	24%	7%	7%	8%	3%
Control	55%	5%	11%	8%	7%	2%	3%	1%	9%

Note. Condition (focus/objective). (*) External focus. Percentages are the mean of reported scores

4.3.1 Order of Attention

In addition to participants self-reporting where they allocated their attention, participants were also required to self-report the order in which they attended to each of the listed components (see Table 1). Frequency distributions of order of attention are displayed in Tables 2-5 (see Appendix J-N). Five out of twelve participants in the external/external objective condition first focused on the target, and second on the concentric rings (5/12 participants). The external/internal objective conditions first focused on the target (8/11 participants) and focused second on their stance (6/11 participants). Eight out of twelve participants in the internal/internal objective condition and 6/12 participants in the internal/external objective condition first focused on their stance, and focused second on their grip (8/12 and 5/12 participants, respectively). The control condition had 7/12 participants focus on the target first.

4.4 Consistency of Outcome Scores

To record the golf ball's position on the putting green surface, a quadrant was created. The ball could land either in the target hole (IN), outside the concentric circles (OUT), in the top right quadrant (TR), the top left quadrant (TL), the bottom right quadrant (BR), or in the bottom left quadrant (BL). A frequency distribution of these results can be found in Figures 3-7. These figures illustrate that participants often overshot/undershot the target, irrespective of condition. However, the external/external objective condition and the internal/external objective condition decreased the frequency they overshot/undershot the target throughout acquisition and retention sessions. The internal/internal objective condition, external/internal objective condition, and the control condition remained consistent throughout acquisition, retention, and transfer in overshooting/undershooting the target.

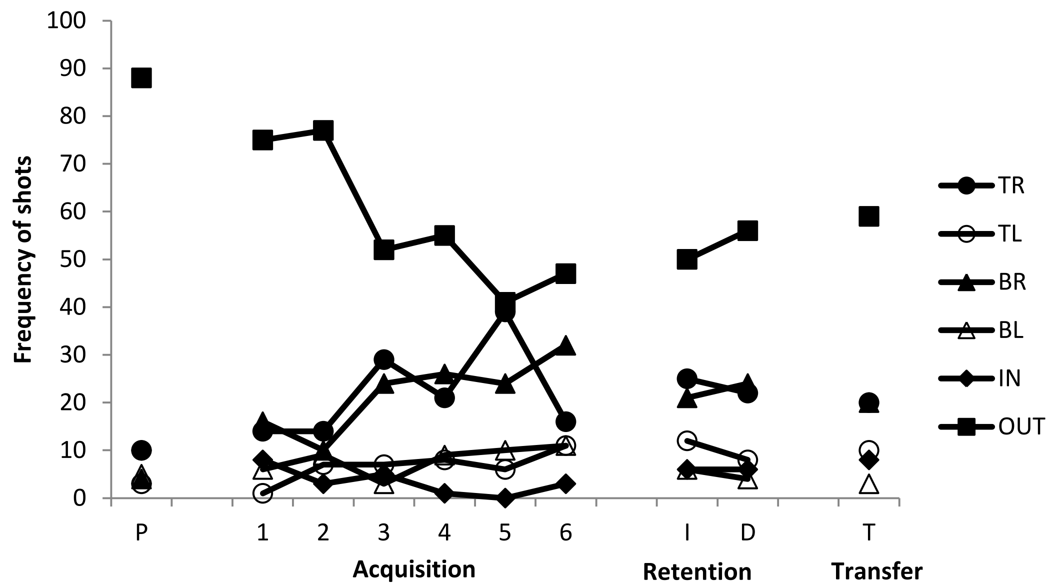

Figure 3. Frequency of shots for the external/external objective condition for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment. *Note:* top right (TR), top left (TL), bottom right (BR), bottom left (BL)

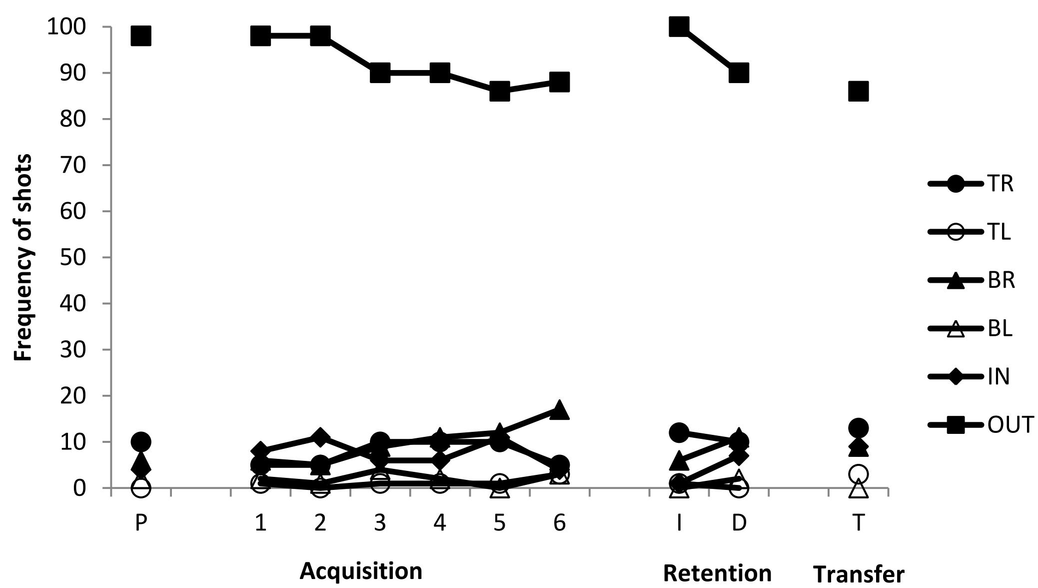

Figure 4. Frequency of shots for the external/internal objective condition for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment. *Note*: top right (TR), top left (TL), bottom right (BR), bottom left (BL).

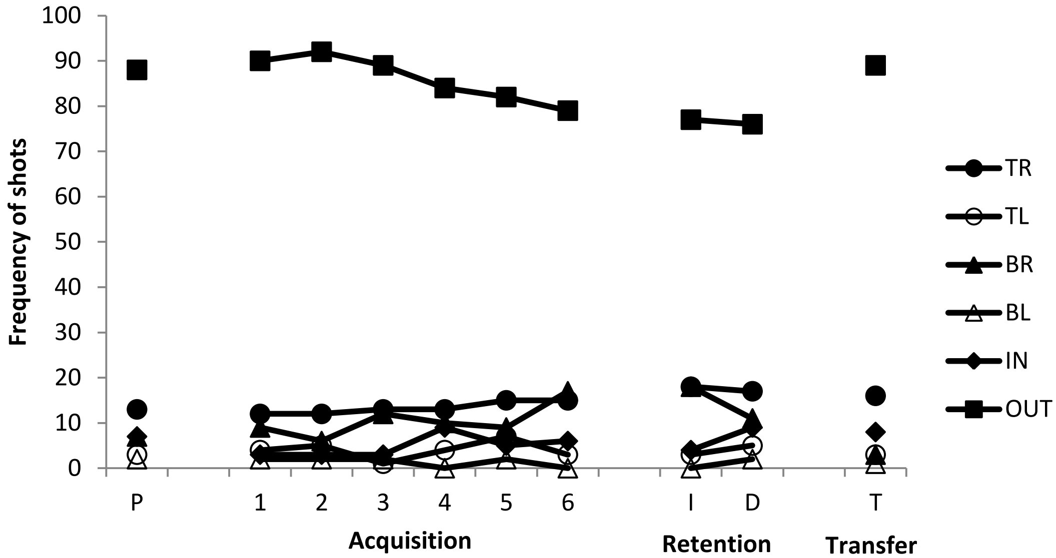

Figure 5. Frequency of shots for the internal/internal objective condition for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment. *Note:* top right (TR), top left (TL), bottom right (BR), bottom left (BL).

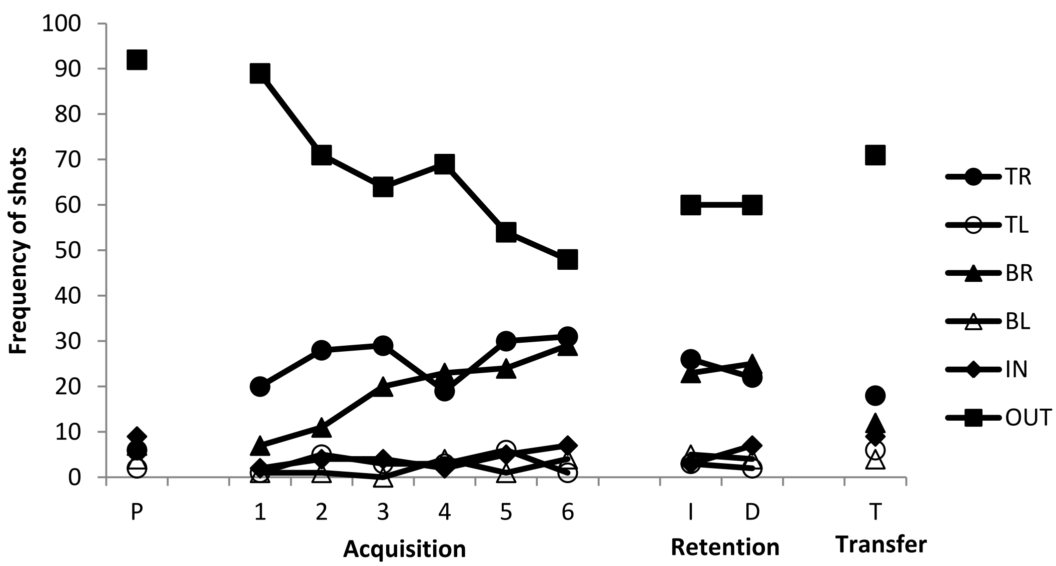

Figure 6. Frequency of shots for the internal/external objective condition for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment. *Note*: top right (TR), top left (TL), bottom right (BR), bottom left (BL).

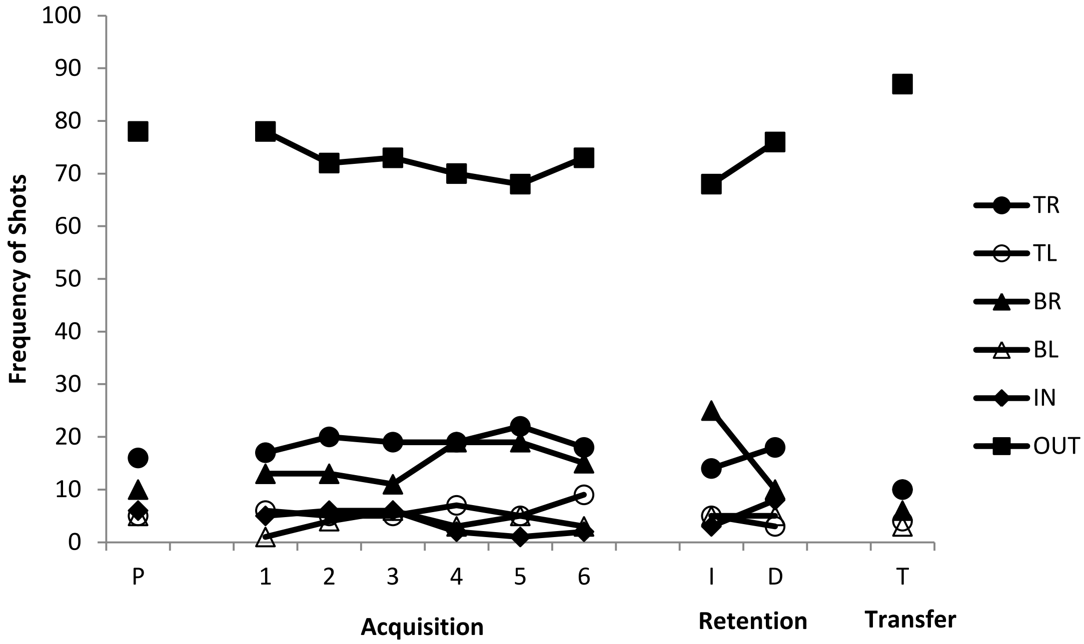

Figure 7. Frequency of shots for the control condition for the acquisition session (blocks 1-6), the retention sessions (immediate and delayed), and the transfer session of the experiment. *Note*: top right (TR), top left (TL), bottom right (BR), bottom left (BL).

5.0 Discussion

The purpose of the present thesis was to examine if a consistent relationship between attentional focus (i.e., external or internal) and task objective (i.e., external or internal) would facilitate greater performance and learning compared to an inconsistent relationship in a golf putting task. The following predictions were made: First, the external/external objective condition was expected to have greater outcome scores than all other conditions, during all experimental phases. This prediction is based on findings from the focus of attention literature, where adopting an external focus is advantageous in performance and learning when the task objective is external (Al-Abood et al., 2002; Marchant et al., 2007; Porter et al., 2010b; Schücker et al., 2009; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007). Second, the internal/internal objective condition was expected to have greater technique scores than all other conditions, during all experimental phases, based on a consistent relationship between focus of attention (internal) and task objective (internal) (Jackson & Holmes, 2011). Based on the results of the present experiment, the first prediction was partially supported, and the second prediction was not supported. A discussion of these findings follows.

5.1 Outcome Performance

The first purpose of this thesis was to determine if consistency between attentional focus (i.e., external or internal) and task objective (i.e., external or internal) would facilitate greater outcome scores in a putting task. Based on existing literature, it was hypothesized that the external/external objective condition would have higher outcome scores than all other experimental conditions during acquisition (Wulf et al., 1999; Wulf & Su, 2007), retention (Wulf et al., 2001a; Wulf et al., 2002), and transfer

(Totsika & Wulf, 2003). This prediction was based on the findings from the focus of attention literature where an external focus was advantageous for performance and learning when the task objective was also external (Al-Abood et al., 2002; Marchant et al., 2007; Porter et al., 2010b; Schücker et al., 2009; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007). Based on the outcome data for the experimental conditions, this prediction was only partially supported. The results showed that the external objective conditions (score as many points by landing the ball into the target) performed with greater accuracy (i.e., higher outcome scores) than the internal objective conditions (score as many points as possible by adhering to the instructed technique), in acquisition, retention, and transfer, regardless of attentional focus (i.e., internal or external). A self-reported questionnaire completed at the end of the acquisition period served as a manipulation check to ensure focus of attention instructions were adhered to. The results from this questionnaire confirmed that participants adhered to the required attentional focus instructions (refer to Table 1), and thus provides additional support for the learning advantages of an external task objective. Specifically, participants who were given an external focus of attention (i.e., external/external objective; external/internal objective conditions) reported focusing primarily on the target (40%). In comparison, the internal/internal objective and the internal/external objective condition dedicated a greater amount of attention to various aspects (i.e., grip) with both conditions focusing more on shoulders/forearms (21% and 24%, respectively) and stance (23% and 19%, respectively).

The results of the present experiment are consistent with previous research that also showed no statistical differences on outcome scores between an external and internal focus of attention in a putting task (Poolton et al., 2006), a soccer task (Uehara, Button, & Davids, 2008), and a balance task (Maxwell & Masters, 2006). Collectively, the authors speculated that learners switched their attention from one cue (i.e., internal cues) to another (i.e., external cues), despite being given a specific instructional strategy (i.e., external focus). Although attentional instructions were adhered to in the current experiment, the self-reported questionnaire supports the notion that learners focused on multiple sources, varying from internal and external cues, independent of attentional focus condition. For example, the external/internal objective condition focused primarily on the target (40%) and concentric rings (9%), and also reported focusing on their stance (11%), grip (18%), shoulder/forearms (8%), hips (3%), knees (5%), and lower body (4%). These findings suggest that while participants focused primarily on their given attentional instructions during acquisition, participants tended to switch their attentional focus between internal and external cues (refer to Table 1).

An external task objective was also superior to an internal task objective, regardless of focus of attention in the transfer test. A transfer test can assess the adaptability, or generalizability of learning by having participants perform a novel variation of the practiced task (i.e., putting with a lighter foam practice ball, as in the present study) (Edwards, 2011; Wulf, 2007a). The ability to transfer the practised task to a novel situation, can measure the strength of learning (Edwards, 2011). Despite the importance of a transfer test, previous focus of attention research has typically utilized retention tests to examine learning effects (Wulf et al., 2001a; Wulf et al., 2002; Wulf & Su, 2007). Therefore, one unique contribution to the existing research is the use of a transfer test in the present study. The findings of the current study suggest that the learning effects of relaying an explicit external objective were not limited to the specific practiced task, but also transferred to a novel variation of that skill, which typically is the goal of learning.

The literature to date has persistently demonstrated that focusing on the effects of movement on the environment (i.e., external focus of attention) enhances skill acquisition (Wulf et al., 1998; Marchant et al., 2007; Porter et al., 2010c). This advantage has been explained through the constrained action hypothesis. According to this hypothesis, an external focus of attention promotes the motor system to naturally self-organize, thus allowing movements to be controlled by automatic processes (McNevin et al., 2000; McNevin et al., 2001; Wulf et al., 2001a; Wulf et al., 2001b; Wulf & Prinz, 2001). However, since there were no performance or learning benefits from adopting an external focus of attention (external/internal objective and external/external objective conditions) the present investigation fails to support the constrained action hypothesis. The results from analysis of outcome scores demonstrated that informing participants of an external *task objective* (i.e., scoring as many points as possible by landing the golf ball into the target) was advantageous, regardless of focusing internally or externally. Therefore, the current study highlights the theoretical limitations of the constrained action hypothesis. Discrete tasks that require a specific technique (i.e., golf putting), as in the present experiment, may cause the learner to switch their attention to multiple internal and external cues, despite being instructed to induce an external focus. Further, providing participants an external task objective with either an internal or external focus of attention, the learner seemingly understood how they were being assessed and therefore developed a strategy to achieve higher outcome scores. Therefore, the results of the present experiment suggest that the constrained action hypothesis cannot explain how focus of attention is modulated by the effects of task objective. Theoretical interpretations will be further discussed in section 5.4.

Similar to Poolton et al. (2006), Uehara et al. (2008), and Maxwell and Masters (2006) a null effect of focus of attention was found. However, the outcome results of the current investigation highlights the importance of informing the learner of an external task objective, when assessing outcome, compared to an internal task objective in both performance and learning. Two important points will be discussed to address this finding: First, the importance of relaying pre-practice information and second, the avoidance of *goal confusion*.

Highlighting the outcome as the task objective could have led participants to interpret task-related intrinsic feedback to help refine ball placement. Pre-practice information provided to participants that describes the task objective and how to achieve the task objective (i.e., technique) is a critical component in facilitating motor skill acquisition (Hodges & Franks, 2002; Williams & Hodges, 2005). During the cognitive stage of learning, providing clear instructions concerning the task objective, whether it is an outcome or a particular movement template, has suggested to be the primary goal (Fitts & Posner, 1967; Hodges & Franks, 2002). In the present experiment, providing the participant with an internal objective (i.e., scoring as many points as possible by adhering to the instructed technique) encouraged the learner to primarily concentrate on achieving high technique scores (see figure 2). Consequently, emphasis was taken away from the external effects of the action (i.e., outcome), thus losing a degree of accuracy (i.e., lower outcome scores) (Hodges & Franks, 2002; Williams & Hodges, 2005). Overall, if outcome is the variable that is being assessed in the motor task, the results from this investigation suggest that providing an explicit outcome task objective will facilitate learning.

However, it is possible that participants who were given an outcome objective were able to concentrate on achieving higher outcome scores by interpreting their intrinsic feedback to improve their scores over trials. Intrinsic feedback refers to information that is available from the task, derived from audition, vision, tactile and/or proprioception (Sidaway, August, York, & Mitchell, 2005). Provided that visual and auditory feedback was not available, proprioception (i.e., information from Golgi tendon organs, muscle and joint receptors) was the primary source of intrinsic feedback for the motor task utilized in the present experiment (Schmidt & Lee, 2011). Participants often overshot/undershot the golf ball in the acquisition period, irrespective of experimental condition (refer to Figures 3-7). The external/external objective and the internal/external objective conditions gradually decreased the frequency they overshot/undershot the target throughout acquisition, and retention sessions. In comparison, participants in the internal/internal objective and the external/internal objective conditions were consistent in overshooting/undershooting the target in acquisition, retention, and transfer. Since the external objective conditions were informed of an external goal (i.e., score as many points as possible, by landing the ball into the target hole) it is possible that participants relied more on interpreting their own intrinsic feedback to accurately calibrate the appropriate force and trajectory to refine ball placement. Hence, participants in the external objective conditions used the task-related intrinsic feedback to develop an error detection and correction mechanism to make the necessary outcome performance adjustments (i.e., decreasing force) (Guadagnoli & Lee, 2004). It is plausible that participants in the internal objective conditions did not rely on intrinsic feedback to calibrate the appropriate *force or trajectory* to improve their outcome scores, since their primary objective was to increase technique scores. Therefore, participants in the internal objective conditions used the available intrinsic feedback to correct movement coordination rather than refining accuracy of the shot. Future research should explicitly examine the potential interaction of attentional focus and task objective on the development of error detection and correction processes in the learner.

A second explanation to consider in regards to why an external task objective was more advantageous than an internal task objective, is that they received a clear external objective (i.e., increase outcome score), resulting in the avoidance of *goal confusion* (Gentile, 1972). *Goal confusion* occurs when the performer, in addition to the external objective, is also instructed to learn the correct movement pattern (internal objective), and this is suggested to come at the expense of outcome scores (Gentile, 1972). This often occurs when a coach or experimenter makes the goal of a task a movement variable (i.e., technique or movement amplitude) (Gentile, 1972; Hodges & Franks, 2002; Williams & Hodges, 2005). Therefore, the learner's attention is focused on movement coordination, resulting in minimal cognitive resources to concentrate on achieving the outcome goal. In early acquisition, the abundance of initial information (i.e., when a learner has both internal and external task objectives) is suggested to overload the information processing of the learner, consequently hindering outcome scores (Marteniuk, 1976; Guadagnoli & Lee, 2004). In the current investigation, participants in the external objective conditions were informed that the only variable being assessed was outcome (i.e., scoring as many points possible by landing the golf ball into the target). Therefore, their emphasis was towards achieving the external outcome goal.

However, participants in the internal objective conditions are believed to have experienced goal confusion. The putting task was chosen given the identifiable internal (adhering to various aspects of the proper technique) and external objectives (landing the ball as close as possible to the target hole) required to successfully perform the task (Pelz, 2000; Wright, 2010). Participants in the internal objective conditions were informed that the only variable being assessed was technique. However, it is possible that they were naturally aware of the external goal (i.e., land the ball into the target) due to the nature of a putting task and being able to see the target/concentric rings prior to their shot, creating an ideal practice context for facilitating goal confusion. Both internal objective conditions self reported focusing on the target (internal/internal objective condition 17%; external/internal objective condition 40%), confirming that they were aware of the external goal while performing their shot. Despite the internal/internal objective condition receiving no external focus of attention instructions or an external task objective, participants inferred an external goal. Since the internal objective groups had the explicit goal of achieving high technique scores and inferred the external goal of placing the ball into the target, it is possible that the information processing system became overwhelmed, causing performance on outcome to suffer (Marteniuk, 1976; Guadagnoli & Lee, 2004). Therefore, it is suggested that future research examining the interaction of task objective and focus of attention should further inspect the role of *goal confusion* by utilizing a task that has equal emphasis on both internal and external goals.

In summary, inconsistent with the focus of attention literature, an external focus of attention was not found to be advantageous, when measuring outcome scores, as would be expected based on the previous research (Marchant et al., 2007; Porter et al., 2010c; Wulf et al., 1998; Wulf & Su, 2007). Similar to studies by Poolton et al. (2006), Maxwell and Masters (2006) and Uehara et al. (2008), no attentional focus differences were found, due to participants focusing on various sources (internal and external cues). However, the present study is unique in highlighting the learning advantage associated with an external task objective, when assessing outcome. This advantage was not only demonstrated in retention, but more importantly seen in the transfer session. Ultimately, the results suggest that it may be unnecessary to provide focus of attention instructions, but providing an explicit task goal is necessary for both performance and learning. Therefore, this study highlights the theoretical limitations of the constrained action hypothesis, by demonstrating the importance of relaying an external task objective, rather than an external focus of attention (see section 5.4).

5.2 Technique Performance

The second purpose of the present thesis was to further examine if consistency between an internal focus of attention and an internal task objective would facilitate greater technique in a golf putting task. Based on existing literature, it was hypothesized that the internal/internal objective condition would have higher technique scores than all other experimental conditions, during all experimental phases. This prediction was based on the consistency between task objective (i.e., internal) and focus of attention (i.e., internal) (Jackson & Holmes, 2011). Based on the technique data for the experimental conditions, this prediction was not supported. The results showed that the external/internal objective and the internal/external objective conditions performed with greater technique scores than the external/external objective condition, in acquisition, retention, and transfer. There were no statistical differences between the internal/internal objective condition and all other experimental conditions, during all experimental phases.

Previous literature has explored the effects of attentional focus in tasks where outcome (i.e., speed or accuracy) was assessed (Al-Abood et al., 2002; Marchant et al., 2007; Porter et al., 2010b; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007). However, the present thesis was unique based on the fact movement technique was assessed during all phases of the experimental protocol. Based on the findings from the present thesis, instructing learners to adopt an external focus of attention did not lead to superior technique scores in all experimental sessions, unless paired with an internal task objective. The constrained action hypothesis predicts that an internal focus of attention interferes in the control processes that regulate movement coordination (McNevin et al., 2000; McNevin et al., 2001; Wulf et al., 2001a; Wulf et al., 2001b; Wulf & Prinz, 2001). Interestingly, an internal focus of attention was found advantageous for performance and learning when paired with an external task objective. The results of the present experiment suggest that providing technique information, whether it be an internal focus of attention (i.e., focus on various aspects of the proper putting technique) or an internal task objective (i.e., adhere to the various aspects of the proper technique to maximize scores) was the practice factor modifying learning, rather than an external focus of attention. Therefore, the findings of the current study fail to support the constrained action hypothesis, and highlight the theoretical limitations, since an external focus of attention was only found advantageous when paired with an internal task objective. Further theoretical interpretations will be further discussed in section 5.4.

The internal/external objective condition and the external/internal objective condition resulted in higher technique scores than the external/external objective condition, not only in acquisition and retention, but also in transfer. The transfer test in the current experiment used a novel variation of the practiced skill (putting with a lighter foam practice ball) to assess the generalizability of learning (Wulf, 2007a). Since the learning advantage of relaying technique information (internal/external objective and external/internal objective conditions) was not only limited to the practiced task, but also generalized to a novel variation, the utility of combining objective and focus of attention in an inconsistent relationship is further emphasized when learning movement technique.

An explanation to consider why the external/external objective condition had inferior technique scores in relation to the internal/external objective and external/internal objective conditions in all experimental phases is the lack of technique information provided during skill acquisition. This finding was expected since technique information was not given to participants in the external/external objective condition. The importance of providing technique information is consistent with the fundamental idea behind the challenge point framework (Guadagnoli & Lee, 2004). This framework suggests that for learning to occur, the learner must be challenged by providing the optimal amount of interpretable information, and this optimal challenge point depends on skill level and task difficulty (Guadagnoli & Lee, 2004). The internal/external objective and external/internal objective conditions were both provided with the optimal amount of outcome and technique information to create the necessary problem-solving processes to make movement performance adjustments. Technique information was necessary to cue participants to the assessed components of the task (i.e., no motion from the lower body), consequently, maximizing technique scores. Either information source (internal focus of attention or internal objective) was equally as effective in learning the proper technique of a golf putt when paired with outcome information (external focus of attention or external objective). The external/external objective condition did not receive either an internal objective or an internal focus of attention, and learning the correct movement template cannot occur in the absence of technique information (Guadagnoli & Lee, 2004). Certain researchers have suggested that learning the dynamics of the skill (technique) will naturally develop over practice through discovery learning, and therefore providing little technique information is beneficial to the learner (Smeeton, Williams, Hodges, & Ward, 2005; Handford, Davids, Bennett, & Button, 1997; Vereijken & Whiting, 1991). However, based on the lower technique scores in the external/external objective condition during all experimental phases, it appears that discovery learning may not be the best instructional approach, since participants did not naturally develop the appropriate movement template (Smeeton, Williams, Hodges, & Ward, 2005; Handford, Davids, Bennett, & Button, 1997). In addition to providing technique information, providing the optimal amount of outcome information facilitated learning since the task had either an inferred external goal (external/internal objective condition) or an explicit external goal (internal/external objective condition).

Interestingly, there were no statistical differences between the internal/internal objective condition and all other experimental conditions. The internal/internal objective condition was provided with technique information, however, they did not have information regarding the outcome goal. Given that the task has a natural external outcome (i.e., target hole), participants may have benefitted from having an indication of both goals (internal and external). It is possible that the inconsistent conditions made the appropriate movement performance adjustments based on how they interpreted their outcome success. If participants felt their putt was unsuccessful, this cued them to the given technique information to make the necessary corrections. Therefore, providing participants with either an external focus of attention or an external task objective, in addition to technique information is a plausible explanation to why the internal/internal objective condition was not superior to the external/external objective condition.

In summary, the results of the present experiment are the first to show a learning advantage to providing technique information, either as an internal focus of attention (i.e., focus various aspects of the proper putting technique) or an internal task objective (i.e., adhere to the various aspects of the proper technique to maximize score), to help cue participants to the assessed components of the task. This advantage was not only demonstrated in acquisition and retention, but more importantly in the transfer session. Jackson and Holmes (2011) suggested that a consistent relationship between task objective (i.e., internal) and focus of attention (i.e., internal) would facilitate greater learning. Interestingly, this study found that inconsistency facilitated greater technique acquisition (i.e., internal/external objective and external/internal objective conditions). The findings of the experiment further highlight the theoretical limitations of the constrained action hypothesis (see section 5.4). Ultimately, providing the appropriate technique and outcome information was the factor to modulate optimal learning, when assessing technique.

5.3 Practical Application

The present thesis has expanded our knowledge and could potentially aid in the development of effective coaching programs. Researchers over the last decade have recommended to coaches that an external focus of attention should be induced for superior learning results (see Wulf, 2007; 2012 respective reviews). However, the current study proposes that the beneficial effects of an external focus of attention may have been inadvertently exaggerated. When analyzing the current outcome and technique data, a different coaching strategy may be suggested. In a more outcome based task such as putting or baseball pitching, where typically the primary goal is to land the ball into a target location, it appears that giving a clear external goal is the most advantageous for learning. The present study suggests that providing technique information was not a necessity in achieving higher outcome scores. Therefore, the coach's main emphasis should be to provide a clear external goal. However, if the coach determines that learning the appropriate technique is the primary goal in an outcome based task, coaches should provide both the appropriate outcome and technique information.

Although not statistically significant, it should be noted that the internal/external objective condition showed a trend towards being superior for maximizing both outcome and technique scores (see Figure 1-2). Perhaps, providing an explicit task goal allows the individual to strategize maximizing outcome scores (as addressed in section 5.1), and an internal focus of attention gave the necessary technique information for the individual to learn the proper movement template (as addressed in section 5.2). Therefore, it seems plausible to provide an internal focus of attention with an external task goal for maximizing learning in both technique and outcome. Future research should further investigate the interactive effects of focus of attention and task objective, to determine if pairing an internal focus of attention with an external task objective could potentially lead to optimal learning in both outcome and technique scores. In addition to coaching, the results of this study could also aid in creating more effective rehabilitation, vocational, or recreational programs by ensuring individuals are given an explicit external task objective, when assessing outcome.

5.4 Theoretical Interpretations

The results for both outcome and technique do not support the constrained action hypothesis. Based on the results for outcome, an external task objective was advantageous regardless of attentional focus, and based on the results for technique, inconsistency (external/internal objective and internal/external objective conditions) was found advantageous. Therefore, a theoretical perspective must be offered to help explain a broader range of findings. Specifically, the constrained action hypothesis cannot explain how focus of attention is modulated by the effects of task objective. Guadagnoli and Lee (2004) offer a theoretical perspective known as the challenge point framework which suggests that learning is directly related to the amount of interpretable information available in a performance instance. This recent framework can assist in explaining the current results. It appears that rather than an external focus of attention being the variable leading to optimal learning as predicted by the constrained action hypothesis (McNevin et al., 2000; McNevin et al., 2001; Wulf et al., 2001a; Wulf et al., 2001b; Wulf & Prinz, 2001), the variable that may facilitate learning is providing the appropriate information. The results of the current study suggest that providing an external task goal provides the necessary information to successfully complete the task. When assessing outcome, an external task goal helped navigate the participant to interpret the correct intrinsic information (i.e., how hard the ball was hit), and this provided the information necessary for learning. Furthermore, since participants in the internal objective conditions had the explicit goal of achieving high technique scores and inferred an external task goal, this may have been too much intrinsic information to interpret, causing the information processing system to be overwhelmed (Guadagnoli & Lee, 2004). Furthermore, when learning the proper movement template for a given motor skill, providing information regarding technique is critical for learning. The current study found that providing technique information in the form of an internal focus of attention or an internal task objective was sufficient. It is plausible that providing technique information increased task difficulty leading to further uncertainty and therefore increased the potential information from intrinsic feedback (Guadagnoli & Lee, 2004). Therefore, it may not be a specific attentional focus strategy that led to optimal learning, as previously thought in past research (see Wulf, 2007; 2011 respective reviews), rather it may be the correct amount of interpretable information (Guadagnoli & Lee, 2004).

5.5 Summary

Conclusions drawn from the current thesis suggest that performance and learning benefits associated with inducing an external focus of attention may have been inadvertently exaggerated in previous research (Al-Abood et al., 2002; Marchant et al., 2007; Porter et al., 2010b; Schücker et al., 2009; Wulf et al., 1999; Wulf et al., 2007b; Wulf & Su, 2007). Two important findings have been discussed in this investigation. First, when assessing *outcome performance*, it may be unnecessary to provide focus of attention instructions. However, providing an explicit external task objective is critical for optimal performance and learning. Second, when assessing technique in an outcome based task, it is necessary to provide technique information (either an internal focus of attention or an internal task objective) as well as providing outcome information (external focus of attention or external task objective).

5.6 Limitations and Future Directions

There are certain limitations that must be acknowledged in the present experiment. First, technique was measured using a subjective judging criterion. Although it was not known which experimental condition participants were assigned to, and the rating scale was created to be objective as possible, there may have been rater subjectivity. Therefore, future research should provide an objective and detailed measure of technique acquisition by utilizing a three-dimensional motion analysis. A second limitation of the present study is that the putting task utilized had a greater emphasis on an external goal (target hole). Therefore, for participants in the internal objective conditions who were instructed that their only objective was to learn the proper technique, they may have also inferred the external goal. Despite wearing occlusion goggles, participants were still able to see the target prior to their shot and during movement production. Future studies could manipulate the task so that participants do not see the target hole prior to their shot. This can be achieved by covering the target hole and concentric circles with a curtain. Furthermore, the transfer test utilized in the present study may have been too close to the practiced task (near transfer test). Therefore, future studies should utilize a far transfer test. In the current experiment, this can be achieved by changing the standard golf putter to a belly putter or to a hockey stick. A final limitation of the present study was that an allocation of attention questionnaire was not given after the completion of both the retention and transfer tests. Future studies could use these additional questionnaires to help determine if participants used similar attentional focus strategies in retention and transfer sessions.

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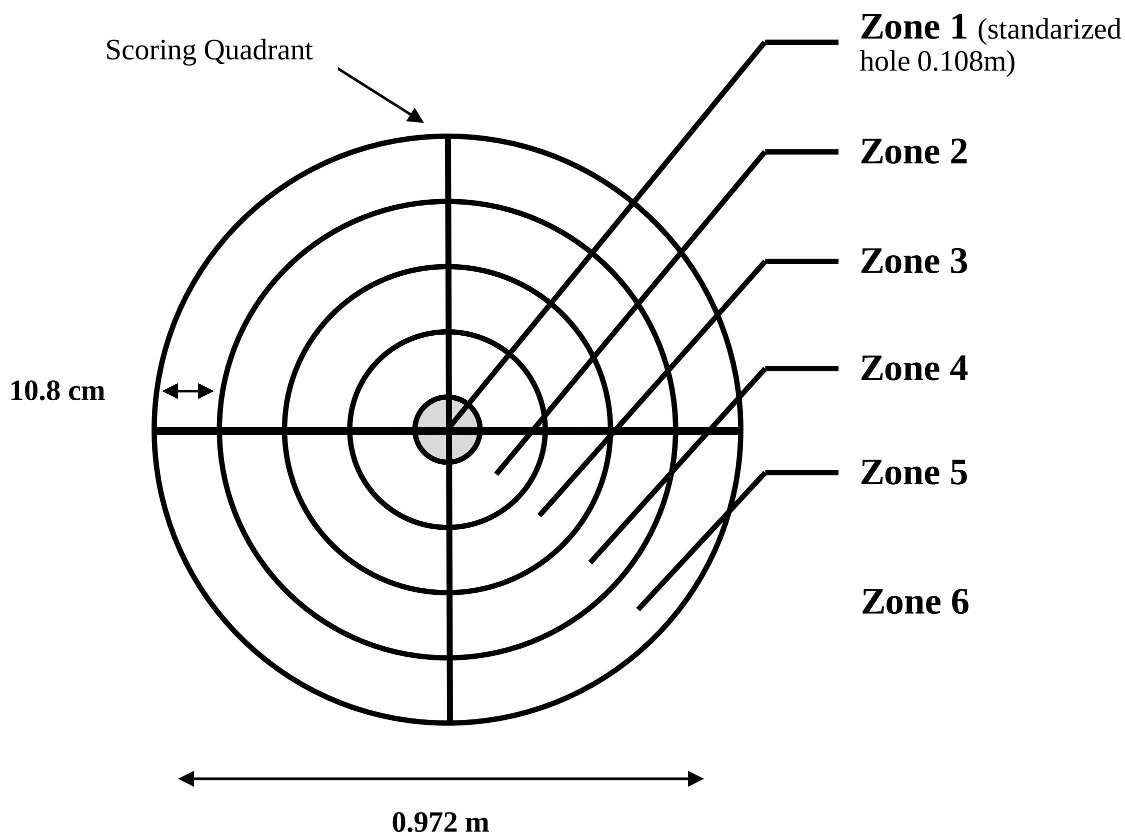
Appendix A

Apparatus

Appendix B

Scoring protocol for external objective



Zone 1 (first concentric circle): 5 points

Zone 2 (second concentric circle): 4 points

Zone 3 (third concentric circle): 3 points

Zone 4 (fourth concentric circle): 2 points

Zone 5 (fifth concentric circle): 1 point

Zone 6: 0 points

Appendix C

Scoring protocol for internal objective

1 point - recognizable **0 points** - not recognizable

A wide stance is required so that the participant's feet are lined up with the center of each shoulder.

☐ 1 point ☐ 0 points

Hips must be bent until the participant's eyes are over the ball.

☐ 1 point ☐ 0 points

Elbows must be slightly flexed and no rotation from the forearms.

☐ 1 point ☐ 0 points

There must not be any motion or rotation from the lower body.

☐ 1 point ☐ 0 points

Knees are required to be in line with each other and slightly flexed.

☐ 1 point ☐ 0 points

Total Points:

Appendix D

Internal and external focus of attention instructions

Instructions	**Internal Focus**	**External Focus**
	1. Focus on keeping a wide stance	1. Focus on the center of the target
	2. Focus on having a slight bend in the elbows without forearm rotation	2. Focus on all the concentric rings surrounding the target
	3. Focus on gently swinging the shoulders and arms	3. Re-focus on the target making it as large as possible.
	4. Focus on keeping your knees slightly flexed and bending your hips	4. Once focused, putt the ball into the target.
	5. Focus on not rotating your lower body.	

Appendix E

Overview of experimental sessions

10 practice trials (without PLATO spectacles)

↓

Overall experimental goal

↓

Basic instructions regarding stance, stroke, and grip

↓

Focus of attention and task objective instructions

↓

Two practice trials (with PLATO spectacles)

↓

Acquisition session (6 blocks of ten trials)

↓

Questionnaire after 60^{th} acquisition trial

↓

15 minute non practice period

↓

Immediate retention (1 block of ten trials)

↓

24 hour non practice period

↓

Delayed retention (1 block of ten trials)

↓

Transfer Test (1 block of ten trials)

Appendix F

Allocation of attention questionnaire

1. Please indicate in the space provided where you allocated your attention while performing your golf stroke (can indicate more than one). If you indicated more than one, estimate the percentage dedicated to that particular aspect (total has to add to 100%), and rank the order in which you attended to each of the circled aspects.

Allocation of Attention (circle)	**Percentage**	**Order of Attention**
a) Target		
b) Concentric rings		
c) Stance		
d) Grip		
e) Shoulders/forearms		
f) Hips		
g) Knees		
h) Lower Body		
i) Other		
Total	**100%**	

2. If you answered OTHER to the above question, please indicate where you allocated your attention while performing your golf stroke.

____

____

____

____

____

Appendix G

Acquisition interaction plot

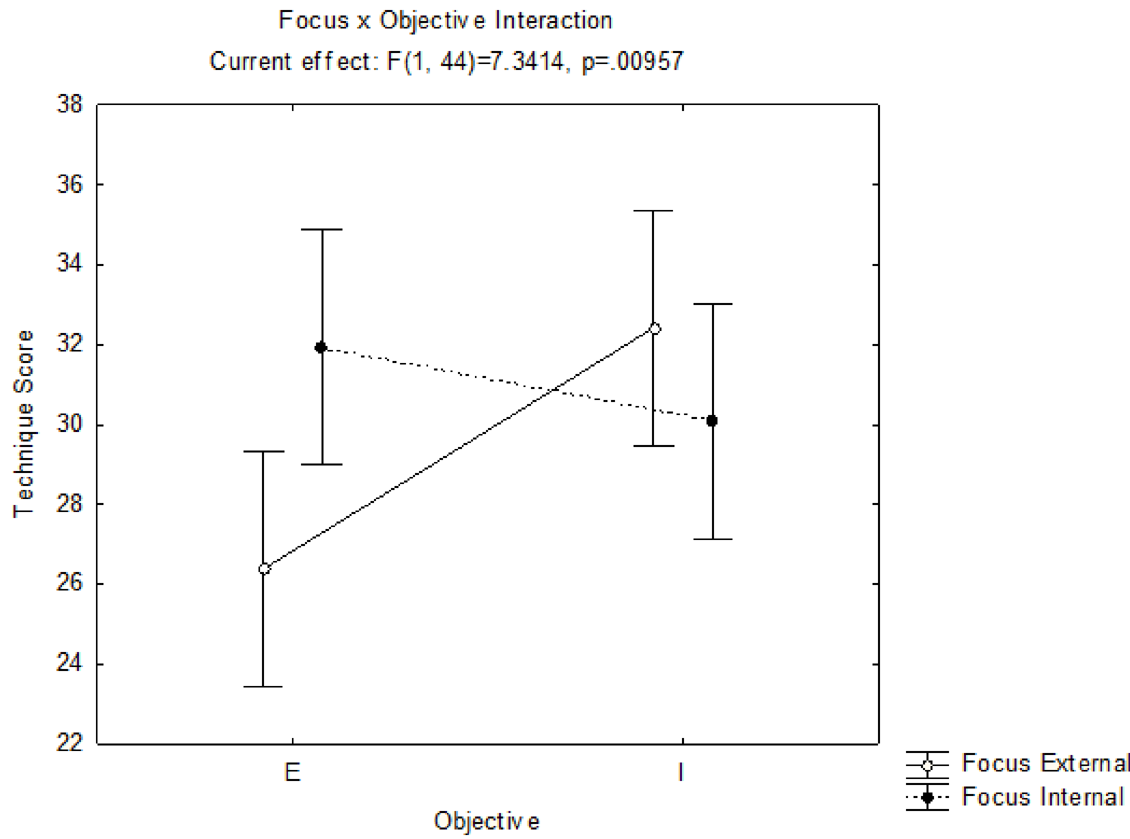


Figure 8. Mean technique scores for the acquisition session (blocks 1-6) of the experiment.

Appendix H

Retention interaction plot

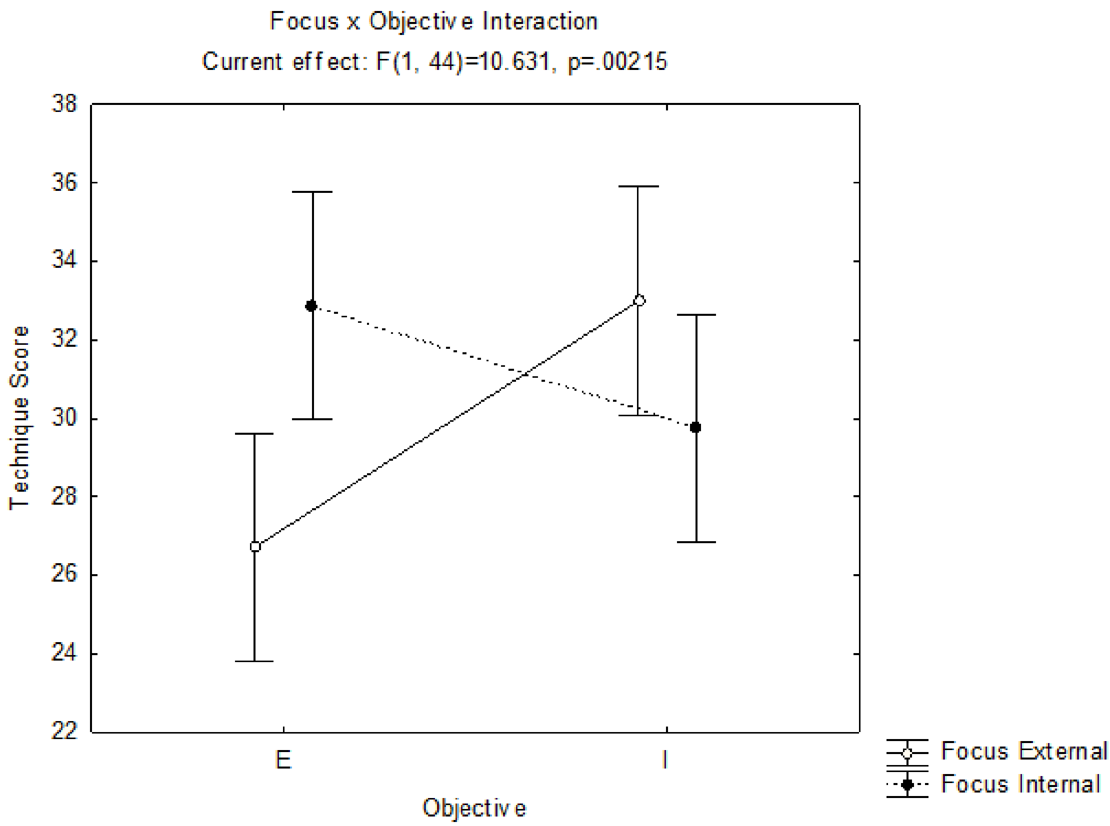


Figure 9. Mean technique scores for the retention sessions of the experiment.

Appendix I

Transfer interaction plot

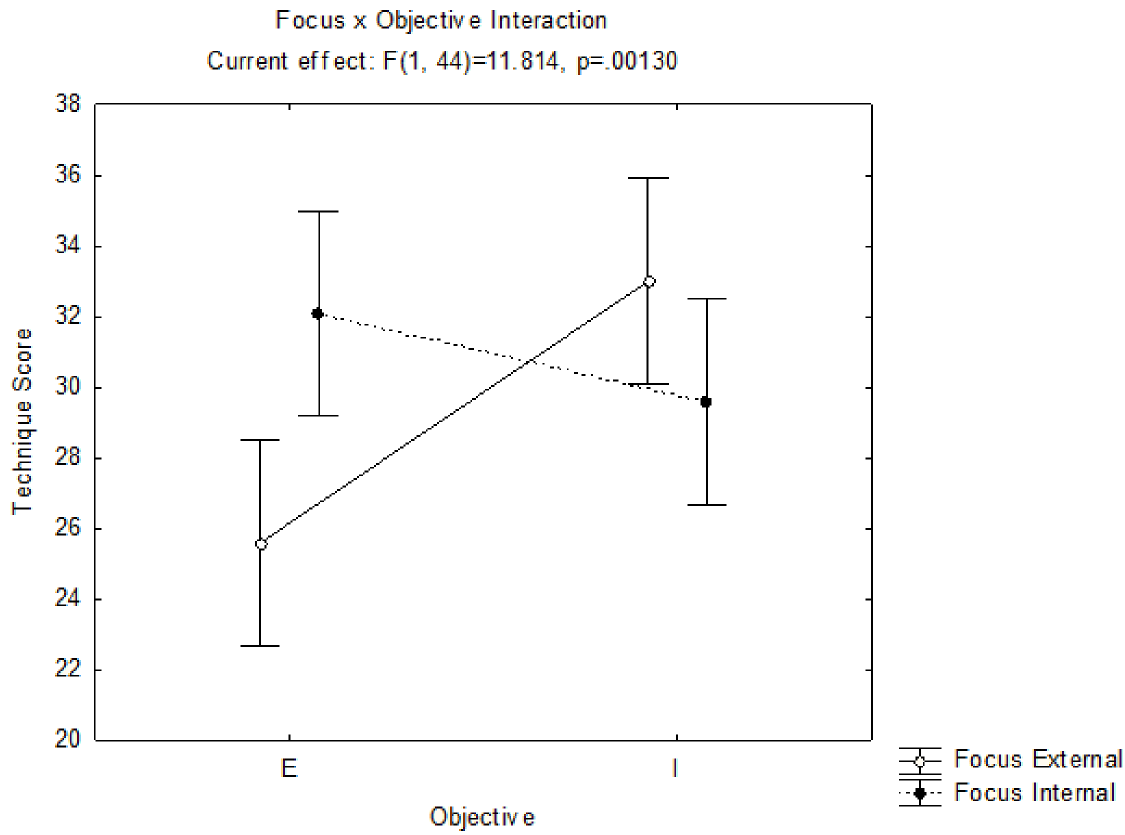


Figure 10. Mean technique scores for the transfer session of the experiment.

Appendix J

Order of attention

Table 2

Frequency distribution of order of attention

Ext/Ext	**1st** **n=12**	**2nd** **n=12**	**3rd** **n=12**	**4th** **n=9**	**5th** **n=7**	**6th** **n=6**	**7th** **n=4**	**8th** **n=1**	**9th** **n=0**
Target	5	3	1	0	0	2	1	0	0
Concentric Rings	0	5	2	0	3	1	0	1	0
Stance	1	1	2	4	0	1	0	0	0
Grip	3	2	4	2	0	0	0	0	0
Shoulders/forearms	0	0	2	1	4	0	0	0	0
Hips	0	0	0	1	0	2	0	0	0
Knees	2	0	1	1	0	0	2	0	0
Lower body	1	1	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	1	0	0

Note: Condition (Focus/Objective).

Appendix K

Order of attention

Table 3

Frequency distribution of order of attention

Ext/Int	**1st n=11**	**2nd n=11**	**3rd n=10**	**4th n=9**	**5th n=5**	**6th n=5**	**7th n=5**	**8th n=4**	**9th n=2**
Target	8	1	0	1	0	1	0	0	0
Concentric Rings	1	1	1	2	1	0	1	0	0
Stance	1	6	1	0	0	0	0	0	0
Grip	1	2	4	2	0	1	0	0	0
Shoulders/forearms	0	1	2	0	0	0	3	1	0
Hips	0	0	1	1	1	1	0	0	1
Knees	0	0	0	3	3	1	0	0	0
Lower body	0	0	1	0	0	0	1	3	0
Other	0	0	0	0	0	1	0	0	1

Note: Condition (Focus/Objective). One participant incorrectly filled out this section of the questionnaire, and therefore had to be removed.

Appendix L

Order of attention

Table 4

Frequency distribution of order of attention

Int/Int	**1st n=12**	**2nd n=12**	**3rd n=10**	**4th n=10**	**5th n=7**	**6th n=5**	**7th n=2**	**8th n=1**	**9th n=0**
Target	1	0	2	1	3	2	1	0	0
Concentric Rings	0	0	0	0	0	0	0	1	0
Stance	8	1	1	0	0	0	0	0	0
Grip	1	8	1	1	0	0	0	0	0
Shoulders/forearms	1	1	2	4	0	1	0	0	0
Hips	0	0	1	0	3	1	0	0	0
Knees	0	2	2	2	1	1	0	0	0
Lower body	1	0	1	2	0	0	1	0	0
Other	0	0	0	0	0	0	0	0	0

Note: Condition (Focus/Objective).

Appendix M

Order of attention

Table 5

Frequency distribution of order of attention

Int/Ext	**1st** **n=12**	**2nd** **n=12**	**3rd** **n=12**	**4th** **n=10**	**5th** **n=10**	**6th** **n=7**	**7th** **n=6**	**8th** **n=0**	**9th** **n=0**
Target	2	0	1	1	3	1	1	0	0
Concentric Rings	0	0	1	1	0	1	1	0	0
Stance	6	4	0	1	1	0	0	0	0
Grip	2	5	0	1	1	2	0	0	0
Shoulders/forearms	2	0	2	0	3	1	2	0	0
Hips	0	0	4	1	0	1	0	0	0
Knees	0	2	3	3	0	1	0	0	0
Lower body	0	1	0	2	2	0	1	0	0
Other	0	0	1	0	0	0	1	0	0

Note: Condition (Focus/Objective).

Appendix N

Order of attention

Table 6

Frequency distribution of order of attention

Control	**1st** **n=12**	**2nd** **n=12**	**3rd** **n=12**	**4th** **n=9**	**5th** **n=5**	**6th** **n=4**	**7th** **n=3**	**8th** **n=1**	**9th** **n=0**
Target	7	1	2	1	0	0	0	0	0
Concentric Rings	0	3	0	0	1	0	1	0	0
Stance	3	3	1	1	0	1	0	0	0
Grip	1	3	3	1	0	1	0	0	0
Shoulders/forearms	0	0	3	2	0	0	1	1	0
Hips	0	0	0	1	2	0	0	0	0
Knees	0	0	1	2	1	2	0	0	0
Lower body	0	0	1	0	1	0	0	0	0
Other	1	2	1	1	0	0	1	0	0

Note: Condition (Focus/Objective).