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By

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Abstract

The rational for this study comes from previous investigations focused on suprapostural tasks that assessed the effect of lower limb manipulation or cognitive tasks on posture. Despite soccer's widespread popularity, there seems to be a lack of investigation on the effect of attentional focus on soccer skills. The present study assessed the effect of attentional focus on a pedal suprapostural (soccer) task on pass accuracy and stance and kicking legs' relative timing. It was hypothesized that inducing external focus of attention would result in superior suprapostural performance defined as higher accuracy and lower errors. The results did not support the hypothesis; however, it is believed that discreteness of the task, short duration of practice and rate on interventions caused instructions not to be effective on soccer wall pass. It is suggested future studies will hold more practice with more trials involved in order to reveal the effects of attentional focus condition on similar tasks.

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Introduction

Attentional Focus and Its Importance

For many years anecdotal evidence has suggested the detrimental effects of focusing attention on body movements during performance, especially in over-learned skills. As interpreted by many investigators (e.g. Wulf & Prinz, 2001), James (1890) stated that directing attention to the effect of movements (their remote outcome) results in desired performance. This aspect has been repeatedly emphasised in existing literature (e.g. Bliss-Boder hypothesis; Bliss, 1892 as cited in Wulf & Prinz, 2001, Henry, 1960., Christina, 1973., Kimble & Perlmuter, 1970; Klatzky, 1984., Masters, 1992., Schmidt, 1988., Baumeister, 1984). Tracing the relation between attentional demands of skill execution and the accuracy of performance and identifying the mechanisms for differences of these attentional demands can make in performance have been the focus of previous studies. Over the past 10 years, attentional focus research has identified that instructions can play a significant role in motor skill acquisition, and offers empirical support for the anecdotal. Specifically, directing performers' attention to the effects of their movements (external focus of attention) appears to be more beneficial than directing their attention to their own movements (internal focus of attention) (Wulf & Prinz, 2001). Today's accumulating literature tends to compare the effects of instructions that induce external versus internal focus of attention on performance and learning of different sport skills.

Internal Versus External Focus of Attention

Studies by Wulf and colleagues (e.g. Shea & Wulf, 1999, Wulf, Hoess, & Prinz, 1998, Wulf, Lauterbach, & Toole, 1999) have shown that instructions phrased to induce an external focus of attention on movement effects can improve performance. This is contrary to an approach promoted by Singer (1985, 1998) which focuses on clues of movement. Wulf and

Weigelt's findings (1997) provided preliminary evidence indicating substantial performance decrements after induction of internal focus of attention as compared to no instructions on a ski simulator task, as well as degraded performance on transfer to an under stress situation. Wulf, McNevin, Fuchs, Ritter and Toole (2000) assessed the effect of focusing on the anticipated outcomes (trajectory of the ball moving towards the learners) versus technique-related (trajectory of the ball moving towards the target) external focus of attention. Their study revealed beneficial effects of technique related external focus over the external attentional focus that was not related to techniques (movement clues). This investigation confirmed that the focus of attention should be directed more towards movement effects and not just de-focusing from the movements itself. The above-mentioned studies refer to performance of well-learned (e.g. Schmidt, 1988., Schneider & Fisk, 1983) or simple motor skills (e.g. Magill & Hall, 1989., 1990., Pew, 1974., Wulf & Schmidt, 1997), which do not necessarily generalize to more complex skills (McCullagh, 1993, Wulf, Shea, & Whitacre, 1998.)

Simple versus Complex Skills

There are numerous variables identified by researchers that affect the learning of simple and complex motor skills, in different manners (Singer, Lidor & Cauraugh, 1993). Organization of practice (Henry & Rogers, 1960, Magill & Hall, 1990), the frequency and type of feedback (Salmoni, Schmidt & Walter, 1984, Schmidt, 1991), the presentation of a model (McCullagh, 1993, McCullagh, Weiss & Ross, 1989) and the provision of physical guidance (e.g. Winstein, Pohl & Lewthwaite, 1994, Wulf, Shea & Whitacre, 1998) are some of the above mentioned variables just to name a few. Recognition of a complex skill is critical because each skill has several different characteristics. Single tasks, such as balancing, in which no more than one motor unit is involved have only one degree of freedom. A task is considered to be complex if it has more than one degree of freedom and cannot be mastered in a single session. For example a balance task combined with a cognitive task, or a balance task that includes balancing on a moving device is a complex task. These characteristics cause easy attention distraction and have ecological validity (Wulf & Shea, 2002).

Level of expertise and attentional demands are additional variables that interact with each other. The higher the level of expertise, the lower the attentional demands on a given task. This reduced attentional demand is accompanied by fewer performance errors in highly skilled performers (Singer, Lidor, & Cauraugh, 1993). To help novice performers reach a similar state of automaticity with less effort and in the least amount of time is a challenging area of research interest.

In an experiment, Wulf, Hoess, and Prinz (1998) demonstrated the benefits of directing attention to movement effects in a complex (ski simulator) sport skill. Their second experiment on a balance task (1998b) examined the efficacy of generalising external attentional focus. The study showed that the benefit of an external focus of attention was not significant during practice sessions; however, significant differences were observed in retention tests. Being a more motor-natured task, balance may not be affected by cognitive intervention strategies, such as given instructions, until a certain level of expertise is reached (Wulf & Weihght, 1998). The similarity in expert ratings of both groups of attentional focus showed that beneficial effects of external focus of attention were not gained at the expense of movement form (See also Wulf, McConnel, Gartner, & Schwarz, 2002).

Attentional Focus and the Effect of Distance

An experiment by Wulf et al. (2000b) revealed the superior performance of novice players who were instructed to focus on the golf club (close proximity) compared to the trajectory of the ball (remote effect). The speculation of optimal distance was obtained from results of Wulf, Lauterbach, and Toole (1999) and McNevin, Wulf, and Shea's (2003) constrained action hypothesis. The first mentioned experiment revealed that external focus of attention (swing of the golf club) is more beneficial in motor performance as compared to an internal focus (participants' arms). The Constrained action hypothesis speculated a remunerative effect of increasing the distance of foci of attention (markers) on a balance task. Wulf, McNevin and Shea (2001) also demonstrated that balance learning was better in participants who had focused on markers on the sticks attached to the platform than external far and near groups who had markers attached to different locations on the stabilometer. Thus, there seems to be an intermediate advantageous distance wherein learners can distinguish the movement effects from body movements and still relate them to the movements they produce.

Attentional Focus and Learning

In an attempt to determine the effect of individual preference on performance and its efficacy in distinguishing the most beneficial focus of attention, Wulf, Shea, and Park (2001) had their participants alternate their focus of attention from trial to trial on a task of matching stabilometer movement with a target that moved in a random pattern over a certain time period. The participants were expected to come to an informed conclusion by the end of practice days. One group of participants chose the attentional condition that they thought was more effective. Significantly more participants picked external focus. It was concluded from this study that external focus of attention is more effective in promoting better performance, whether participants are assigned to a certain type of attentional focus or are to explore their preferences to come up with a decision about the cue they would direct attention to. This fact can be used in learning about more complex sport skills that involve more degrees of freedom and also in attempting to consciously control results to prevent overloads especially in early practice.

As Wulf, McNevin and Shea (2001) argued, the detrimental effects of internal focus of attention are also applicable to more automatic motor processes. The experiment consisted of a primary probe reaction task paired with a secondary balance task using a stabilometer. The external focus of attention group had lower balance errors, which is consistent with previous findings that showed enhanced performance and learning with external focus of attention. This group also showed lower RTs (reaction times) compared to the internal focus group. This finding showed that induction of an external focus of attention results in less attention demands and less interference with automatic control processes of posture. Higher automaticity of performance under external focus of attention consolidated this finding. In agreement with other literature (e.g. Wulf & McNevin, 2003), the external focus group in this experiment also showed lower root mean square errors (RMSE), and higher Mean Power Frequency (MPF) values, both of which are characteristics of superior balance performance in biologic systems with many degrees of freedom. In order to examine the validity of the critics (Woollacott & Cook, 2002) concerning the automaticity of posture (Nashner & McCollum, 1985), Riley, Baker and Schmidt (2003) conducted an experiment on the effect of a memory task on posture. Their results led to the conclusion that participants stabilized their posture to a higher level in order to leave enough cognitive resources to perform the digit memorizing task. Therefore, it can be combined with the findings of McNevin, Wulf (2002) suggesting externally focusing in an additional secondary task does not interfere with the postural control.

Attentional Focus Transfer to Novel Situations

Skills are usually performed in contexts other than the practice environment. The ability to transfer learning is an area of concern in training programs. Apart from developing the best techniques for optimal acquisition, investigators are interested in finding an explanation for suboptimal performance of well-learned skills in under-pressure conditions. This phenomenon has been known as choking under pressure (Baumeister, 1984). Previous investigations (Fisk & Schneider, 1984, Smith & Chamberlin, 1992) that replicated the competition environment with stress and other variations showed the addition of a secondary cognitive task did not negatively affect the performance of skilled athletes; whereas these effects were observed in novice players. Vasiliki and Wulf (2003) conducted transfer tests of riding the dynamic balance apparatus as fast as possible forwards and backwards. In order to prevent participants from adopting instructions given during practice (for a review see Wulf & Prinz, 2001), another task of counting backwards was included. Identical results suggesting superiority of performance in external focus condition in all situations (retention; riding forward, backward, backward combined with counting) in this experiment imply that in a performance-pressure situation with variations in the actual task, external focus of attention is very efficient.

Task Difficulty and Attentional Focus

It seems that external focus of attention is demonstrated only to be more effective when the task difficulty is challenging enough for the learners (Landers et al. 2005). Wulf, Tollner, and Shea (2007) determined the manner in which manipulation of the type of focus influences performance of tasks that require different attentional demands. This can be helpful in isolating the sensitive task characteristics in rehabilitation and motor learning settings especially for practitioners. By leaving the automatic resources available for processing postural control and focusing on the conscious effort of balancing, standing on one leg on an inflated disk, revealed the advantageous effects of external focus (Wulf et al., 2007). Internal focus on the same task resulted in more focus on the automatic capacities involved in control processes and interfered with reflexive processes. Inducing an external focus on demanding tasks provoked the development of motor programs through the continuous practice of the same tasks (Wulf et al., 2007, Moghaddam, Vaez Mousavi, & Namazizadeh, 2008).

Attentional Focus and Suprapostural Control

The influence of suprapostural tasks on postural sway is shown in many previous studies (e.g. Stoffregen, Pagualayan, Bardy, & Hettinger, 2000, Riley, Stoffregen, Grocki, & Turvey, 1999). Presumably the greater accuracy requirement of the suprapostural task is facilitated by adaptively modulating the postural task. This is explained by the utilization of more automatic control processes and reduction of attentional demands. In their investigation McNevin and Wulf (2002) hypothesised that external focus of attention adopted on suprapostural task will leave more resources available for performing the postural task. Riley et al. (1999) did not specifically examine external and internal foci of attention; however, their "touch relevant" and "touch irrelevant" could be related to external and internal focus of attention respectively. It was expected that postural sway would reduce in both conditions with significant reduction under touch relevant condition. A marked postural sway decrease was seen in both conditions; however, the decrease was significantly smaller under touch relevant condition. It is assumed that the outcome was due to the slight differences between internal and external focus of attention.

The previous study was replicated by Wulf and McNevin (2002) who demonstrated higher frequency of responding (MPF) under external focus of attention compared to baseline and internal focus condition. Their finding, which was consistent with increased joint/muscle stiffness (Winter, Patla, Prince, Ishac, & Gielo-Perczak, 1998), suggests the promotion of the use of automatic control processes in balance control (e.g., Wulf, et al., 2001; Sea et al., 2001, Wulf & Prinz, 2001, Woollacott & Cook, 2002). External focus of attention seems to be optimal for ensuring a greater degree of coherence between sensory feedback and movement control. Internal focus of attention resulted in inferior performance only after the addition of a secondary task (Poolton, Maxwell, Masters & Raab, 2006). Despite expectations, both foci conditions resulted in increased postural sway, suggesting differences in instructions and measuring techniques led to differences in outcome. Wulf, Weigelt, Poulter & McNevin (2003) provided evidence for this view by showing the frequency characteristics of balance performance. The external focus group demonstrated movements with higher frequency and lower amplitude, components that are an indicator to the exploitation and integration of the available neuro-motor degrees of freedom and skilled performance. Wulf et al.'s 2003 experiment replicated the hypothesised notions of the beneficial effect of external focus application for the suprapostural performance and directing performer's attention further from the primary balance control during balance learning. The authors of the study interpret the results as being due to the utilization of different motor processes which are promoted by each type of focus. According to the constrained action hypothesis, the more natural control mechanisms are utilized when focus of attention is directed to more distant sources.

Wulf and McNevin (2004) followed up the investigations by examining the reciprocal effects that adopting each type of foci of attention on postural or suprapostural has on the other task. Based on the findings of the previous study they were interested to determine if the addition of a suprapostural task will help improving balance control (Riley et al. 1999, McNevin

& Wulf 2002). The study suggested that task enhancement is task related although there are reciprocal effects of the tasks upon each other as well. Overall adopting an external focus on a supra postural task produced the best results for efficiency in dual tasking. The motor system decides on which input effectors to concentrate, based on the output it is supposed to produce. Basically postural control subserves the suprapostural task which means better postural control will help in the superior performance of the suprapostural task. The economy of the motor system requires it to focus on logically relevant tasks. By focusing on the postural control the suprapostural task becomes secondary or even irrelevant to motor system and the beneficial effects of external focus will not be transmitted to the primary one. This study is in line with motor system optimization for managing control systems based on goal achievement.

The biceps curl study by Vance et al. (2004) found neuromuscular advantages of external focus in explosive sports such as lifting in which the performer needs to exert a maximum force in a short duration. This investigation showed higher MPF, EMG (electromyography which shows the pattern of muscle recruitment) and iEMG (integrated electromyography which shows temporal and spatial characteristics of muscle activity) values for external focus of attention group. The fact that the tasks were performed more rapidly when participants focused on the curl bar movements (external foci) is in accordance with constrained action hypothesis. EMG activity results for the first experiment did not show significant difference. The iEMG results; however, revealed a significant effect of type of attention and repetition. EMG activity was lower under external foci. Experiment 2 controlled for movement time and differences were found in EMG activity. Results suggest a significantly lower EMG and iEMG activity under external focus of attention in flexion phase which is the most important part in a biceps curl. Similar results were replicated in Zachry et al. (2005) in a basketball free throw. In the latter experiment lower EMG values were accompanied by more accuracy in performance.

There are investigations indicating the superiority of internal focus on novice performers (Perkins-Ceccato, Passmore & Lee 2003) or individuals whose automatic control processes are being challenged constantly (Canning, 2005 on people with Parkinson's disease). However some instructions assigned in the above mentioned studies have been vague and not all performers necessarily focused on their body movements in accordance with internal foci instruction. In an investigation on people with Parkinson's Disease Wulf et al. (2009) replicated the similar improving effect of external focus of attention in balance control as compared to internal focus and control condition.

The Role of Instructions on Learning

The results of the above-mentioned studies question the effectiveness of the body-related instructions which are meant to enhance motor performance (e.g., Cox, 1933). These findings are in line with the studies that express the ability of motor system to automatically control the processes (e.g. Henry 1953). Briefly the motor system simply does what the mind intends it to do. This notion is close to Prinz's (1990) common coding explanation for this phenomenon. Overall, these experiments emphasise on the importance of the type of instructions given to a learner. It also reiterates the effectiveness of external focus of attention rather than internal focus of attention.

Instructions are important determinant factors in the learning of new motor skills. (Wulf, Hoess & Prinz, 1998). These instructions have been shown to have a definitive influence on performance and learning. To help beginners attain the automatic strategy used by experts in the quickest possible time is an area of great research interest (Magill, 1998) as the only way known has been trial and error and quality practice. The other side of the index of performance is awareness strategy, which is usually executed by beginners who are instructed to think about their spatial and temporal coordination between various movement components. Singer (1985, 1988) introduced a five-step approach in which the performer mentally prepares him or herself before the performance and uses imagery to achieve the optimal goal of the task. It had traditionally been assumed that learning in early stages occurs by making learners aware of their movement and performance (Adams, 1971, Fitts, 1964, 1967, Schmidt, 1991) with guidance about factors such as timing of their steps, placement of legs and feet and hips and position of body parts in the follow through movement. The instructions and feedbacks that learners and patients are provided with in rehabilitation settings are based on these suggestions, which by considering the following findings that provided proof for the improving effects of external focus of attention (directing attention to movement effects) can be worrisome.

Hypothesis and the Purpose of the Study

Contact sports such as soccer, basketball, ice hockey and rugby entail concurrent processing of information from different resources. Soccer players for instance, are required to perform more than one skill at a time. They combine locomotion, object manipulation and quick decision making based on information processing skills. The necessity to find advanced strategies for both novice and skilled players has led to few studies involving soccer and attentional focus.

Soccer Studies

Conscious processing by Masters (1992- 2000) argues that information accrual will cause deterioration in performance, independent of the type of attentional focus. This theory has paved the way for constrained action hypothesis evoked by Wulf and colleagues (1997 – 2003). Ford, Williams and Hodges (2005) experimented with relevant and irrelevant internal focus of attention on soccer dribbling at different expertise level. From the detrimental effects that internal relevant and internal irrelevant focus of attention had on skilled players, it can be deduced that instructions inducing an internal focus of attention on features of performance interfere with automatic processes. This interference occurs irrespective of whether those features are directly related to the task or not.

Some authors such as Beilock (2004) demonstrated the differential effects of attentional focus on different levels of skill. Among the few studies examining the attentional focus effects on soccer skills, Smith and Chamberlin (1992) conducted their experiment on soccer players of three different levels of expertise. Their intention was to replicate the results of Leavitt (1979) experiment with hockey players. Soccer is accompanied with task element structural interference. All groups experienced a decline in performance following the addition of each task (dribbling, dribbling and shape recognition) and the decline was significantly greater for novice players as compared to intermediate and experts. It seems comparing running to soccer dribbling task is futile. Soccer players are not supposed to run with their highest speed all the time. Running is a fundamental motor skill. Unlike ice-skating (in the case of ice hockey study), running does not include any intermediate objects. Also structural difference as explained in Beilock et al. (2002) (the necessity of looking at the ball or puck in Leavitt's) interferes with the visual secondary task of shape recognition.

With the purpose of examining the efficacy of simply preventing learners from focusing on their movements (as it is the case with Masters 1992, 2000, Beilock et al. 2002, 2004) and Smith and Chamberlin, 1992 experiences) over external focus of attention acquisition, Wulf and McNevin (2003) had their participants perform an attention-demanding suprapostural task in a balancing postural experiment. In addition to the superiority of performance of all external group over internal, attention distracted and control groups there was no such decrement in attention distracted group as seen in Masters (1992, 2000). The differences between the natures of the two tasks, the type of instructions and post-tests used by two researchers must be considered. The second experiment of Wulf et al. (2002) with experienced players performing a soccer lofted pass on different frequencies of feedback types confirmed the efficacy of external focus on feedback as well. The detrimental effects of internal focus feedback was more apparent in high frequencies in spite of external focus feedback that showed improved performance in retention following high (100%) frequency of feedback reception.

Most of the previous investigations focused on suprapostural tasks, assessing the effect of upper limb manipulation or cognitive tasks on posture. There also seems to be a huge lack of investigation on attentional focus in soccer. Postural control has been investigated by using different balance tasks; but there has never been any assessment on pedal standing suprapostural tasks with different requirements on each leg. Soccer specifically puts different demands on both legs as it involves running, spinning, sudden stopping and manipulating the ball in a short amount of time. This study is based on Wulf et al.'s 2000 experiment of hitting a tennis ball (first experiment) and a golf ball (second experiment) at a target adopting two types of attentional focus. The first experimental results showed that the participants who had directed their focus of attention to the movement effect (trajectory of the ball) over antecedent (trajectory of the ball approaching them) exhibited superior performance. In the second experiment learners who had focused on the golf club outperformed the ones who had focused on the trajectory of the shot.

Soccer does not use any apparatus such as a racket or club used in tennis and golf although these implements can be considered extension of the limbs using them. Focusing on the movement of the leg and the part of the foot that touches the ball (implement resulting in the movement effect) will induce an internal focus of attention in this experiment. The only factor analysed in Wulf et al. (2000)'s study was the accuracy of the shot placement demonstrated by scores on each trial. In the present experiment, the relative timing of the support and swinging leg actions were calculated and analyzed in order to determine the effect of attentional focus on performance technique and accuracy of a soccer pass (suprapostural performance) was investigated.

This study addresses multiple questions. The first one is examining the effectiveness of external focus of attention on a "wall" or "one-touch" soccer pass. It basically examines the constrained action hypothesis on a soccer one-touch pass. This effect is assessed by analysing the accuracy of the pass in hitting a defined target. The ability to perform accurate wall or one touch pass gives a good view towards ball control skills. The accuracy of passing the ball to the target is an essential ability in order to transport the ball between team mates especially in tight and fast defending/offending situations. This accuracy hypothetically can be enhanced by employing the right type of attentional focus in coaching instructions. Novice players might benefit greatly as this helps learners reach the automaticity of performance faster.

This experiment also assesses relative timing according to the type of focus of attention. Relative timing is an essential aspect in sports such as soccer. According to the constrained action hypothesis adopting an external focus of attention allows unconscious automatic processes to control the movement which results in an economy in muscle recruitment. Overall, it is hypothesised that smooth movements will be performed under external focus of attention that will be exhibited in similar relative timing to an expert's pattern of relative timing. External focus of attention has been shown to hamper fine movement, reduce noise, and enhance motor movement economy (Zachry et al. 2005).

Another interesting variable to all studies that involve cognitive manipulation is assessing confidence or success in task performance had on maintaining the focus. A questionnaire is provided at the end of trials for each participant to rank their confidentiality in using and keeping the focus of attention they were provided with over the trials.

Methods

Participants

Participants of this study were young healthy adults (University students) between the ages of 18-30 who were not experienced in soccer. The exclusion criterion was having any regular recreational, or any semi-professional or professional experience soccer. Participants were recruited randomly from female and male students who were willing to take part in a kinesiology study. Sample size calculations were based on similar previous studies examining the primary variables of interest. Previous studies on the effects of attentional focus range from 12 participants in studies with repeated measure design to 48 participants in studies including three groups of attentional focus. Twelve participants per group participated in the Wulf et al. 2000 study which had a similar design. A power analysis with GPower software was conducted to determine the number of participants needed in this study (α=.1, effect size= 0.5) and 12 participants per group (overall 36 participants) were deemed sufficient for the study. The statistical information were processed by IBM SPSS statistics software.

Apparatus

Ball Batter

The device used for passing the ball was a frame made of a plywood sheet mounted on a cart. A 4 ft pendulum on a pivot was attached to the plywood sheet. A weight (5 lbs) was attached to the pendulum in order to induce the required velocity. The cart's wheels were locked so it did not to move during the swinging phase of the pendulum. The pendulum was lifted up to 90 degrees manually by the researcher and was held up on a knob. The pendulum was released by a manual trigger to hit the ball towards the participant on each trial. Data collection began once the pendulum hit the ball from its sitting position. A ply wood sheet with a hole in the middle was attached to the system to hold the ball stationary before it is hit. An electrical switch was integrated underneath the holder and it clicked once the ball sat on it. The electrical switch clicked (out) again once the ball left it following the pendulum stroke. This click triggered the data collection on the accelerometers. The researcher announced the sign "ready" vocally to the participant and triggered the pendulum releaser knob.

This ball batter provided a mimic of a teammate passing a ball. The pendulum provided a visual cue for participants so they would be able to coincide this to intercept the pass. This was similar to what happens in real world soccer game or training when the player is able to see their peers getting ready to pass. The movement of the arm from its starting position gave the participant a time to predict the contact time. With the mechanical movement of the arm there was a more natural pattern in predicting the movement.

Soccer Ball

The standard sized and standard inflated ball (FIFA junior standard) was shot 4 m towards the player from a ball batter. The ball was released towards the participants at a velocity of approximately 7.1 $m.s^{-1}$. This velocity was lower than the average velocity of soccer passes (Jacob & Jesus, 1998, Barfield, Kirkendall, Yu, 2002). It was also lower than an instep full kick's normal velocity (Nunome, Lake, Georgakis & Stergioulas, 2006) and closer to instep passes (Jacob & Jesus, 1998) which was deemed sufficient and challenging enough for novice players. Each ball was released from a 45 degree angle that the ball batter made with each participant's standing position. The center of the target was located at 45 degrees of the participant as well. The description of the wall pass defines the best passer as a mirror or wall reflecting the ball back with the same angle it has been passed to them.

Target

A wooden board was attached to the front wall of the laboratory and was used as the target for assessing passing skill. This sheet of wood prevented the laboratory's wall from being hit by several ball strokes and probable consequence damage. The width of those parts of the sheet being in the view of the camera was 228.27m. This dimension was fixed to the view of the camera attached on the racks above the floor. Any ball that contacted out of camera's view was counted as a missed ball. The centre of the target was marked by a cross in black tapes. The edges of the target board were also taped vertically so the participants knew if they had hit the board out of camera's view and as such represented all errors.

Camera

A Logitech Quick Cam webcam was attached to the ceiling's racks in order to visualize the ball position after contact to the target board. Its threshold on a binary image was set the way it recognized the ball as a bright spot on a dark background. The object size was also pre-defined for the camera so it would not recognize any thing significantly bigger or smaller than the soccer ball. The integrated program recorded the centroid of this spot once it contacted the dark background on camera's view. Figure 1 shows the setting of the laboratory.

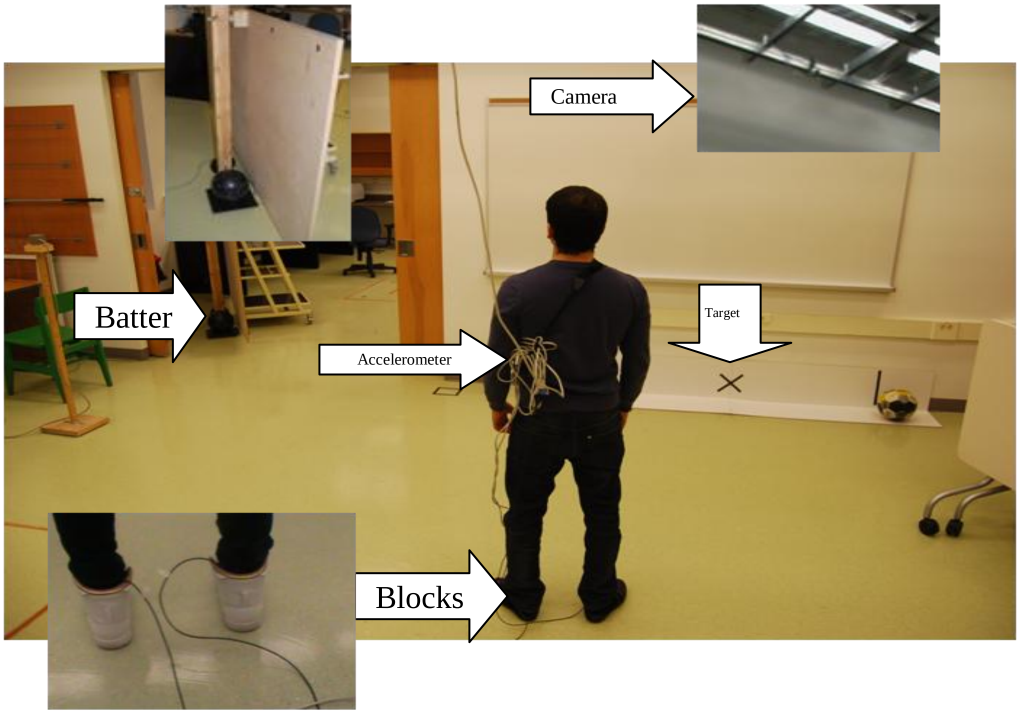

Figure 1- Lab setting

LabVIEW 2010

The camera was integrated to the LabVIEW 2010 program on the data collection computer. The LabVIEW 2010 software digitized the ball position and made it visible on the software. The data viewer depicted the ball position in the format of a signal. This signal remained flat until the ball contacted the target. Once the ball landed on the target board the digitized ball position was visible on the signal as an increase in the signal's amplitude. The X dimension of this signal showed the time point and the Y axis (ball position signal's amplitude) showed the ball position. Ball position was defined between 0 and 1 on the vertical axis in the data viewer. The highest amplitude (1) showed a ball that contacted the left most edge of the target board (behind the target centre) and 0 showed a ball that contacted the right most edge of the target (in front of the target centre). On this scale, 0.5 indicated a ball that contacted the centre of the target (right on the cross, optimal performance). Any ball that hit the wall out of camera's view showed no signals on the viewer.

Accelerometers

In order to record the participants' timing of the kicking and stance leg two accelerometer blocks were used. The MMA7331L:XYZ AXIS ACCELEROMETER which is a low power, low profile capacitive micro-machined accelerometer featuring signal conditioning, a 1-pole low pass filter, temperature compensation, self test, and g-Select which allows for the selection between two sensitivities was used. Zero-g offset and sensitivity were factory set and require no external devices. The MMA7331L physical features are: 3mm x 5mm x 1.0mm LGA-14 Package and conjunct wire which made it comfortable enough for placing inside participants' footwear. The wire made them suitable for moving with participants' legs for tracking the timing of their movements. This device is commonly used in 3D gaming, pedometer and robotics for tilt and motion sensing and event recording.

The 3-axis accelerometer contains an onboard single-pole switched capacitor filter. Because the filter was realized using switched capacitor techniques, there was no requirement for external passive components (resistors and capacitors) to set the cut-off frequency. The accelerometer enabled us to assess the timing and amplitude (magnitude of the force at hitting at the step and kick) of the movement of each leg.

Procedures

Participants watched a quick instruction video (two minute length) which included two main parts after habituation to the study. In the first part, they were familiarized with soccer wall pass and then watched a video of the researcher performing the task in the lab environment, which also introduced them to the task and the devices used in the study. In order to induce external, internal or general attentional focus each video had a distinguishing which included a paused section during pass performance in the video. The first pause was at the stance phase and the second pause was made at the kicking phase after the ball left the foot. For the external focus of attention condition, an arrow pointing to the ball was added to the picture (see figure 1). For the internal focus of attention condition, the same arrow was added pointing to the foot (See figure 2). No arrows were added to general focus of attention group in the movie. The arrows were used as a visual augment to instructions which either had participants focus on their instep contacting the ball (internal) or ball (external) foci (see fig. 2 and 3).

Figure 2- Paused picture in external focus group instruction video, emphasising on external (ball) cue

Figure 3- Paused picture in internal focus group instruction video, emphasising on internal (foot) cue

Participants received the ball from approximately a 4 m distance, which encouraged them to take one step forward and pass the ball towards the target. The step forward movement let them reach the proper position for passing. Each participant was given three baseline trials before their leg acceleration, timing and performance were recorded. After baseline trials the accelerometer blocks were placed in participants' footwear and 20 recorded trials were performed. Each participant passed the ball 20 times. They were instructed that their goal was to hit the centre of the target (right on the cross).

Condition	External	Internal	General
General Instruction	Pass the ball to the centre of the target		
Attentional focus instruction	Focus on the angle of the ball leaving you foot	Focus on the angle of you foot	Pass the ball to the centre of the target

Table 1 - Attentional focus instructions, as provided to the participants

Data Processing

Ball position score transformation: Accuracy of data capturing technique

In order to assess the accuracy of data capture technique and clarify that there was a linear relationship between the actual placement of the ball on the target board and the digitized transformation of it on the data viewer, a measuring procedure was performed. Five places on the board were measured with a measuring tape and their equivalent Y-axis values on the viewer were recorded. For finding a linear relation between the pixels and the ball position across the board, equivalent scores of 0.1, 0.25, 0.5 (centre) 0.75, and 0.9 were measured on the board with a measuring tape. The centre of the target was marked as 0 and the metric values increased as we moved further from the centre towards right hand side. The metric values decreased to negative as we moved towards the left hand side of the target centre. The outcome graph showed an almost linear relation between the actual spot of the ball on the target and its equivalent digital display on the data viewer signal. The equation that defines the transformation of the board metric score to pixel scores (from 0 to 1) is as follows:

y=-228.27x+112.87

$R^2 = 0.9998$

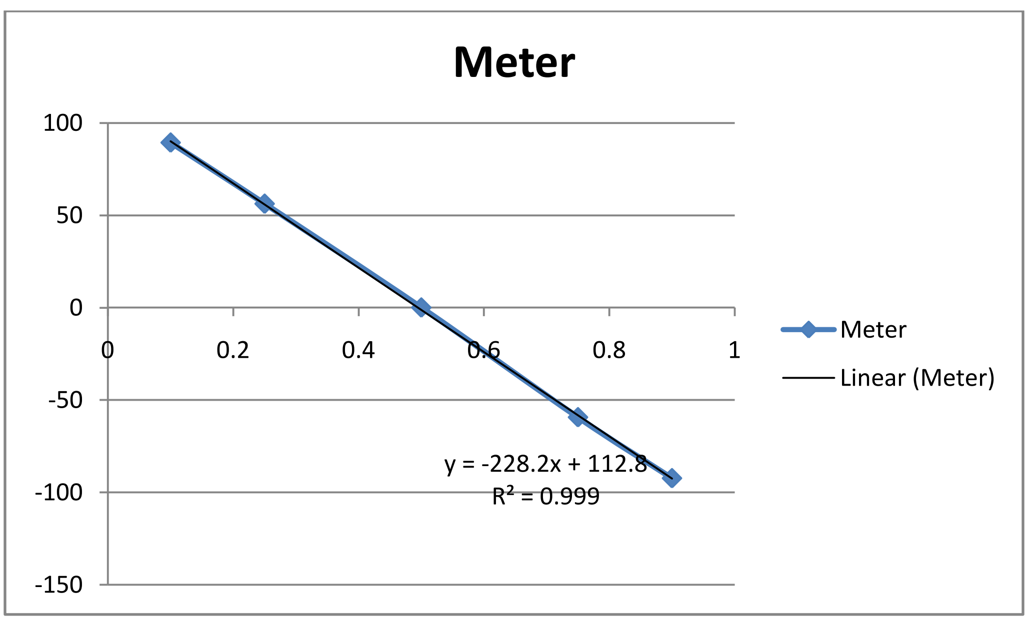

Figure 5 - The equation and linear relationship used to transform the metric scales on the board to pixels on the data viewer.

Ranking scores and errors

After defining the ball position in pixels there was a need to score the data the way that optimal performance held the least amount of error while the further the ball got from the centre of the target errors increased. The present ball position data ranking from 0 to 1 were on a continuous scale which could not show the exact amount of error regardless of where the ball had landed. In order to do so, the same transformation equation was used to transform the data to metric values. With this criterion perfect performance in this experiment was scored zero meaning there was no error involved. Each ball that did not land right on the target obtained a value equal to their distance from the target centre in centimetres. This value was taken in for further analysis.

The resultant graph shows the absolute error distribution of ball positions after transforming the scores to metric values.

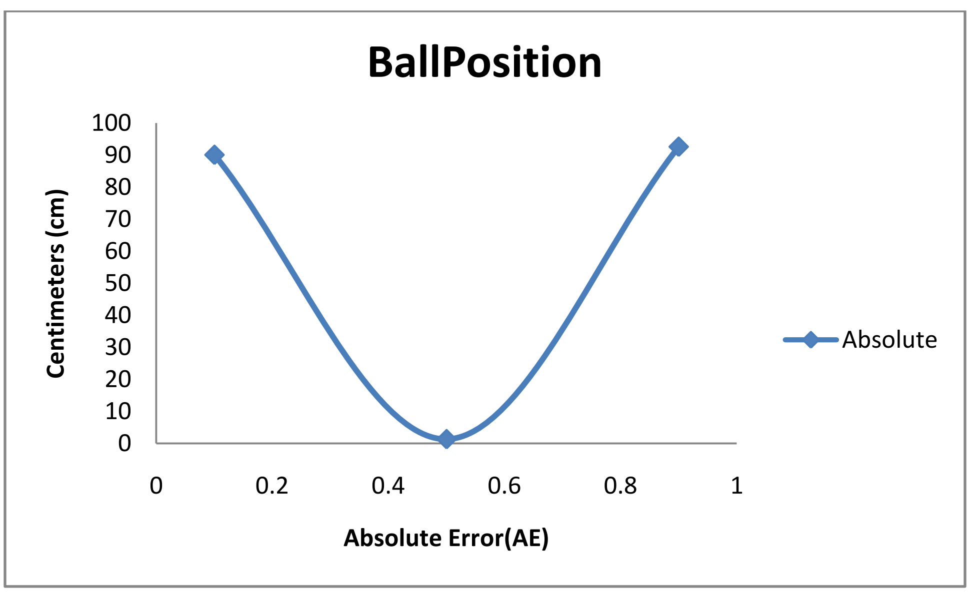

Figure 6- Ball position scores in absolute errors

Performance Assessment

1- Missed Balls (MB)

Most of the participants were unable to pass the ball to land it across the target board for all of their trials resulting in several none-score-able trials. The number of unsuccessful trials was taken into account for the primary analysis of participants' gross performance. The number of missed balls was taken as an assessment of performance to clarify if any significant differences among attentional focus groups might interfere with interpretive results.

2- Constant Error (CE)

The constant error (CE) shows the sum of participants' targeting deviation bias from the target. The actual metric values (errors) of each participant were averaged for all trials to obtain the CE.

3- Absolute Error (AE)

Performance errors were assessed after missed balls were excluded from the data being analysed. Absolute Error (AE) was calculated in order to assess the overall accuracy of their performance by taking the absolute values of each trial's error. AE values were averaged for all trials before analysis.

4- Variable Error (VE)

Variable error was calculated for this data by taking the standard deviation of the trials and is an indicator of their consistency in hitting the target.

5- Relative timing (RT)

The Data viewer showed accelerometer signals in three dimensions. There were 8 accelerometer signals obtained overall, of which only the resultant acceleration values were considered for data processing in order to find the relative timing. The output displayed the resultant signals of all three dimensions for both legs. The resultant signals were used in order to calculate the relative timing. For each resultant signal X axis shows the time points and the Y axis shows the amplitudes of each signal. To calculate relative timing the resultant signal's peak values on the X-axis obtained from left (stance) leg was subtracted from the peak value of the right (kicking) leg. The results for all trial from every participant were averaged and analysed.

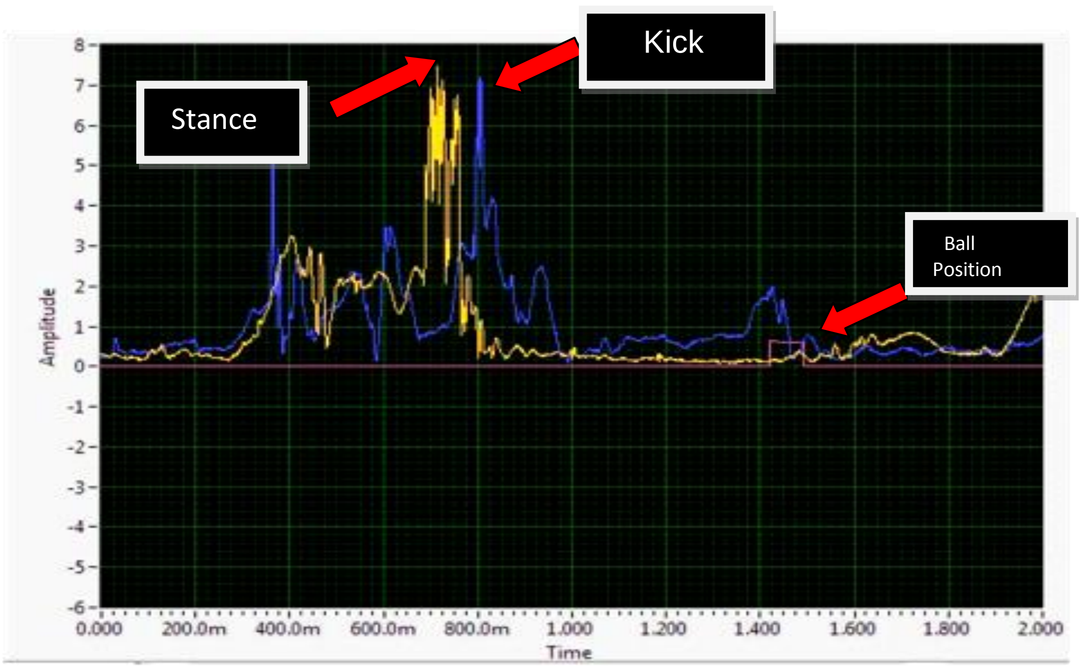

Figure 7- A sample of signals on the data viewer

Results

All analyses were performed at a more liberal value α of .1 in order to accommodate the exploratory nature of the study. A primary analysis on the number of missed balls included a

Chi-square test in order to test any relationship between the number of the missed balls and attentional focus. Separate One way Analysis of Variance tests with three levels of attentional focus (external, internal, and general) were performed on the remaining dependent variables (CE, AE, VE and RT, respectively) in order to clarify any significant difference between scores and timings. Descriptive statistics for all variables are shown in Figure 13.

1- Missed Balls (MB)

A Chi-square test was performed on missed balls and focus conditions in order to determine whether missed balls were equally distributed across attentional focus conditions. The analysis did not reveal a relationship between attentional focus and the number of missed balls, χ^2 = 6.086, P >.1, suggesting no association between attentional focus and number of the balls participants missed, and is illustrated in Figure 8.

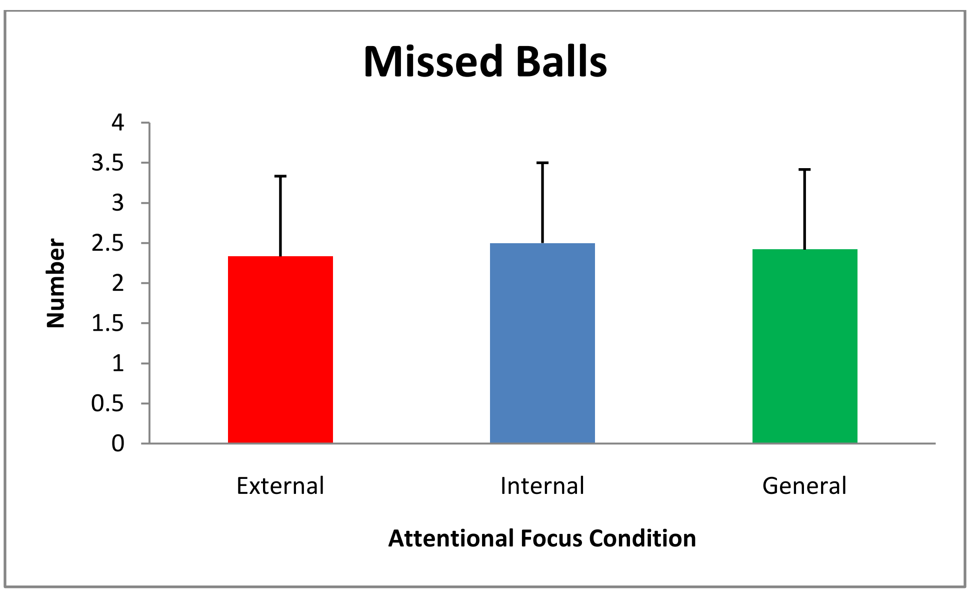

Figure 8 - Number of missed balls across attentional focus

2- Constant Error (CE)

After excluding missed balls from the data, analysis of CE data revealed no significant main effect as a function of attentional focus, F (2, 33) = .353, p > .10, suggesting no bias with respect to kicking performance as a function of attentional focus (see Figure 9).

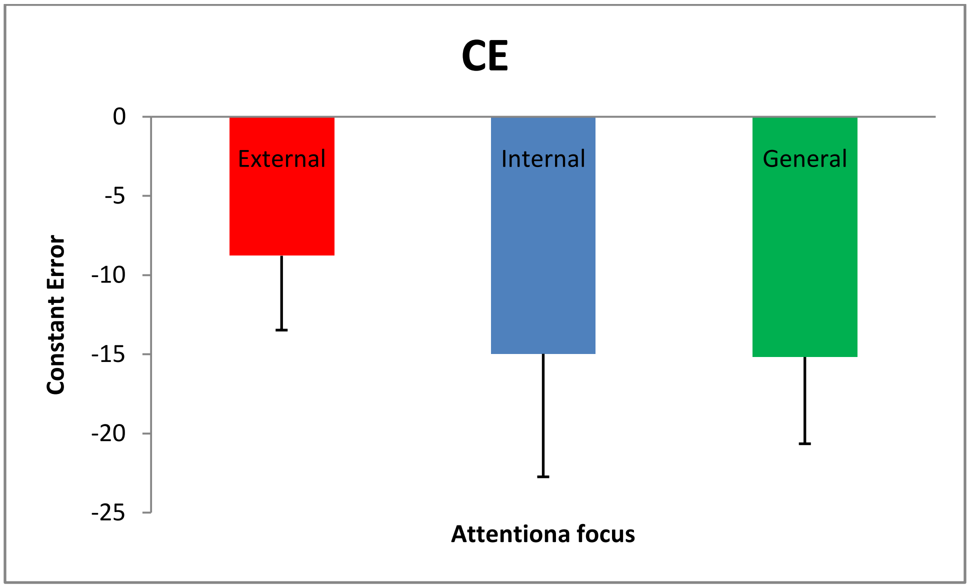

Figure 9 - CE as a function of attentional focus

Absolute Error (AE)

AE data were analysed after excluding missed balls from the data. This analysis also failed to reveal any significant effect of attentional focus on AE, F (2, 33) = 2.106, p > .10 (see Figure 10).

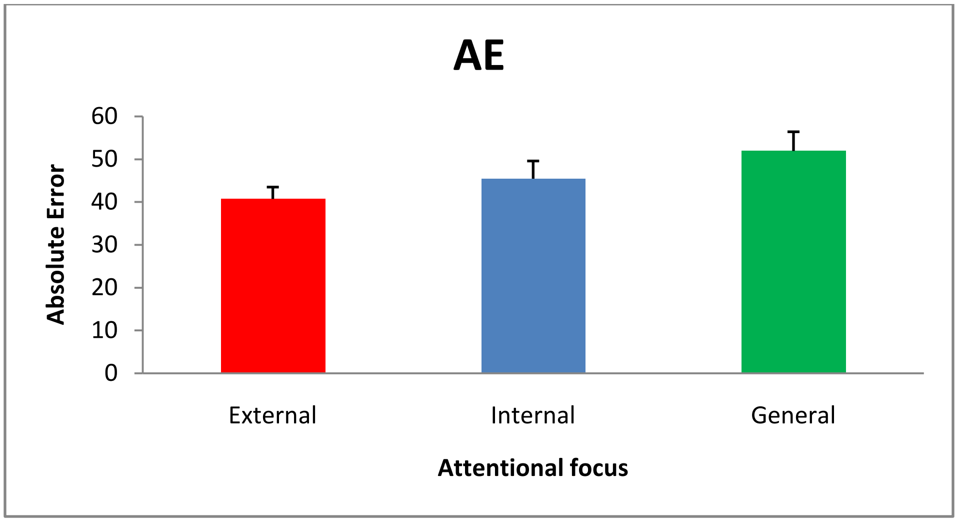

Figure 10 - AE as a function of attentional focus

3- Variable Error (VE)

Analysis of VE data revealed a significant main effect of attentional focus, F (2, 33) = 2.947, p = 0.09. While Figure 11 suggests both external and internal focus conditions resulted in lower VE compared to the general focus condition. However, the Student-Newman-Keuls post hoc test failed to discriminate between the means.

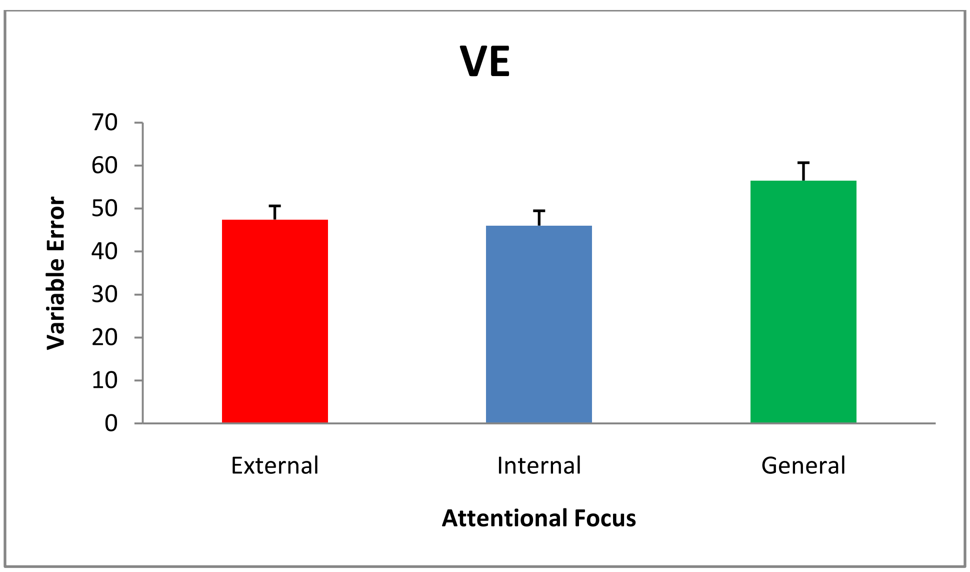

Figure 11 - VE as a function of attentional focus

5- Relative Timing (RT)

To assess if there was any difference between the relative timing of the stance and kicking leg during the performance as a function of attentional focus, relative RT values were analysed. This analysis failed to reveal any significant main effect by attentional focus on RT, F $(2, 33) = .104$, $p > .10$, suggesting similar relative timing performance regardless of attentional focus condition.

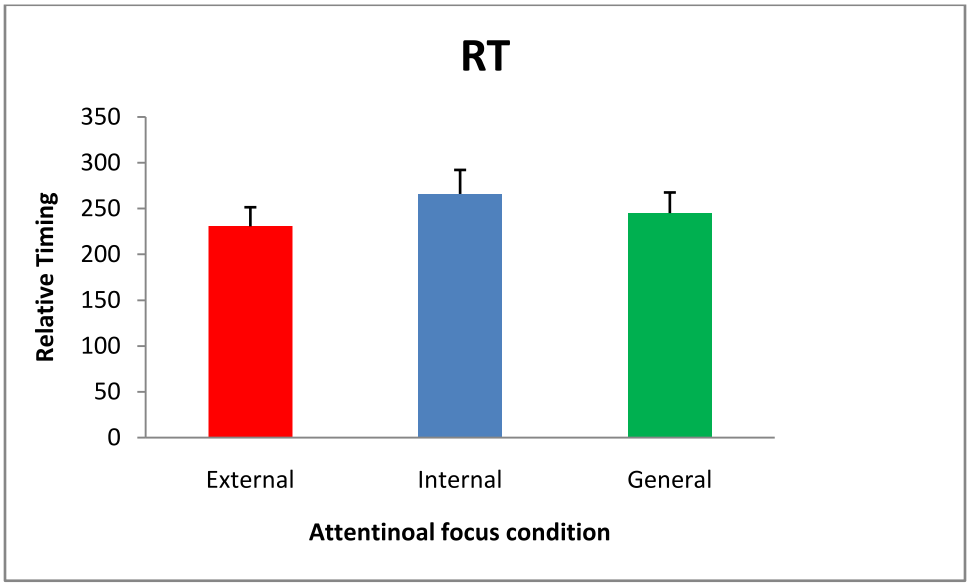

Figure 12 - Relative timing as a function of attentional focus

Descriptive Statistics

Focus	Constant Error		Absolute Error		Variable Error		Relative Timing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
External	-8.7795	16.25714	40.7017	9.59794	46.9774	11.36459	230.6125	72.05770
Internal	-14.9696	26.91036	45.4367	14.31248	44.5008	11.25580	265.9250	90.76432
General	-15.1725	18.97543	51.8942	15.57244	53.5779	10.83246	244.9958	78.13307

Table 2 – Descriptive statistics table

Levels of focus and confidence

It is recommended researchers should consider posing post-trial questions to the participants to ensure that the instructions are understood and the focus is maintained (Wulf, Landers, Lewthwaite, & Tollner, 2009). A short questionnaire was administered to participants after their trials in order to assess their confidence in focusing on the attentional cue, and also to assess how useful the instructions were. They were asked to rate their level of confidence in using the instructions provided on a 10-point scale (Confidence: 1=Not confident; 10=Very confident). The second question asked them to rate how easily they were able to focus their attention on the cue provided (Focus: 1=Not effective; 10=Very effective).

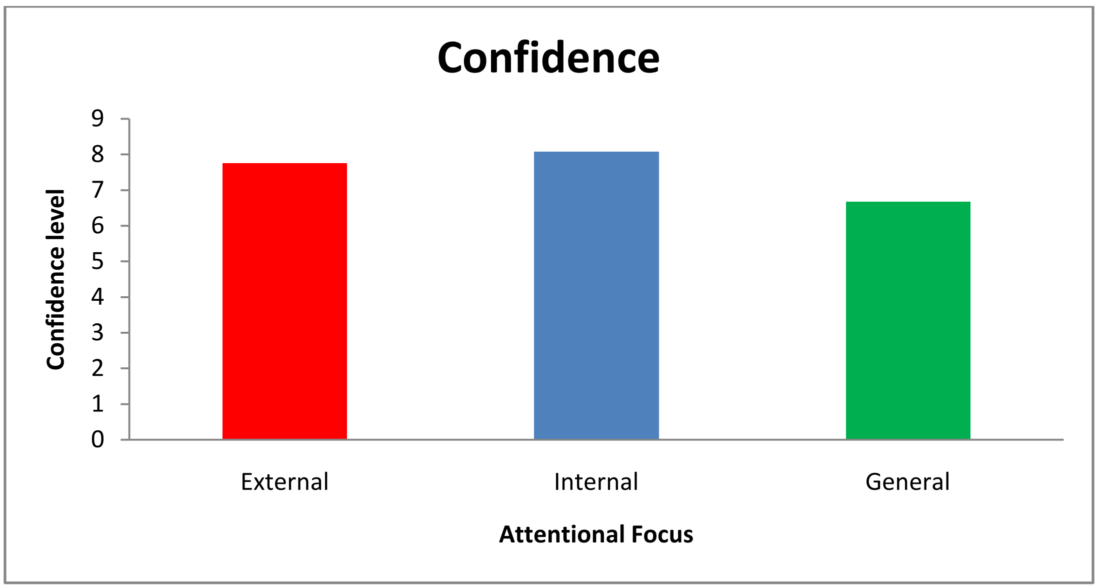

Figure 13- Levels of participants' confidentiality in effectiveness of instructions

It is evident from confidence and focus level bar charts that most of the participants in all three attentional focus conditions had high levels of confidence in the effectiveness of instructions. This shows that instructions seemed to be effective from the participants' point of view (see Figure 13). The ease in maintinaing this focus (see Figure 14), however, suggets that both groups of particiants receiving specific cues related to the activity (i.e., internal and external focus instructions) found the instructions effective. Based on the results of the previous analyses, however; subject reports are not necessarily indicative of perfomcance outcome.

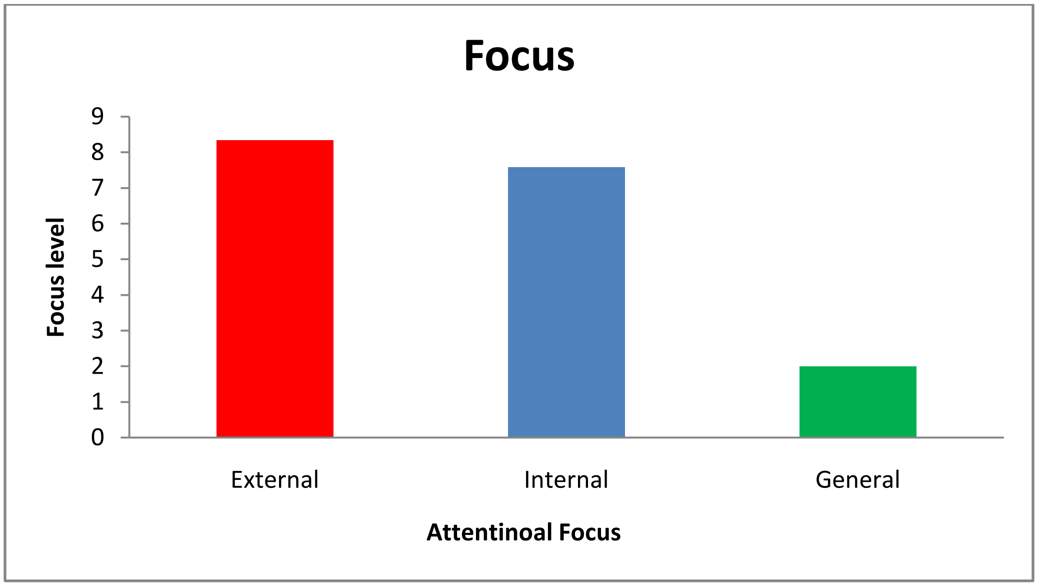

Figure 14 – Levels of participants' confidentiality in focusing on the instructed cue of attention

Discussion

This study attempted to assess the effect of attentional focus on a pedal suprapostural task. The soccer wall pass was used in this study in order to verify the effect of obtaining different attentional focuses on targeting and passing with the foot among novice soccer players. The participants of this study were University of Windsor students chosen based on the soccer background. Any student between the ages of 18 to 30, with no or little background in playing soccer qualified for the study. The external attentional focus condition consisted of directing attention to the movement effect (the angle of the ball leaving participants' foot). The internal attentional focus condition consisted of directing attention to the action (the angle of participants' foot instep). The general attentional focus condition consisted on no specified clue of movement and participants in this group were only provided with general instructions.

According to the hypothesis of the present study and previous studies on constrained action hypothesis, the external focus of attention group participants were expected to outperform those in the internal and general focus groups and obtain lower errors (lower AE and VE also certain bias in CE). The results did not completely support the hypothesis. It failed to reveal any significant main effect of attentional focus on overall accuracy (AE). It also failed to reveal any significant difference in bias in passes (CE). It was also hypothesized that a significant effect of focus of attention would be observed on the values of relative timing; however, there was no significant difference between attentional focus groups' relative timing which suggests focusing on different cues of attention did not result in a significantly different step and kick timing among novice players.

The only dependent variable the analysis on which revealed a significant main effect of attentional focus was VE however; Post hoc tests failed to discriminate between focus conditions. This result does not completely agree with the constrained action hypothesis. Based on previous research, it is expected that external focus condition group would show lower VEs compared to both internal and general conditions with internal condition having the highest VEs. In the present study's results; however, internal focus condition has the lowest VE.

One of the limitations that could be considered is participants' athletic background; however, the relevant graph shows a normal trend. Most of the participants had some experience in recreational sport activity. This study assessed the effect of attentional focus and sport back ground has never been considered a factor in similar research.

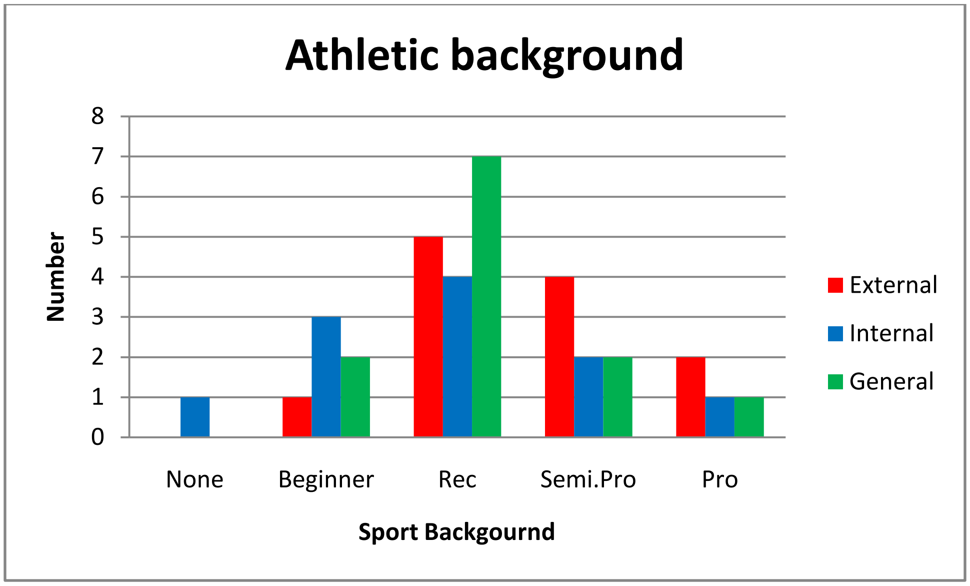

Figure 14 – Participants' athletic background distribution

There was no significant effect of attentional focus on the overall performance as investigated on their AE data. This outcome could be related to the fact that these participants were all at early stages of learning and any significant variability of overall performance could not be evoked by inducing attentional focus before they get more practice. This task might need more practice in order to let the effect of attentional focus sink in and represent performance differences on the given dependent variables. No significant effect of attentional focus on participants' CE results only reveals that there was no particular bias in their targeting. Participants in early stage of learning did not show any tendency to differ in hitting the target centre on the left of right side of it so CE values did not significantly differ across trials. Similarly if there is an optimal relative timing it could only be presented once the participant uses the attentional focus during performance.

There are certain factors to this study which should be addressed when compared to other attentional focus research. This was the first research that assessed the effect of attentional focus on a discrete soccer task which took less than 2 seconds to complete. After 20 trials each participant had an experience of practicing the task about 1 minute overall which is very short compared to the other tasks that usually require more practice time, and allow for more focus of attention effects to emerge. It should be noted that previous studies had a considerable amount of time for each trial (e.g., Wulf et al., 2003 had their participants perform suprapostural task for 90s in each trial). Although participants had a fairly good performance on their ability to perform a new suprapostural task, with which they were not familiar; the amount of practice they received could be looked at as one of the limitations of the study. A sample of novice players with very little to no experience in an unfamiliar task tend to perform similarly and may simply not benefit from attentional focus instructions before a certain level of proficiency has been attained.

Another important factor that might have impacted the ability to find an attentional focus effect was the discrete nature of the task. This limitation is more obvious in research such as the present study, which investigated the effect of attentional focus on a very fast and unfamiliar task. The discrete nature of the task itself may have led to so much effort put in pedal control by participants that fewer resources were available to devote to the attentional focus instructions. Although the velocity of the ball was reduced to half of the normal velocity one might encounter in an actual game or practice, intercepting the ball was still very challenging, as could be inferred from the number of balls missed. Participants' ratings on post experiment questionnaire show a high level confidence and focus in their performance. This ability in performing a novel task also showed that this task has the potentiality of being learned in a short amount of time; however, performers might not be able to use the induced attentional focus during a short practice time. Participants might have used imagery and paid attention to the cue of movement right before each task had started but could not use attentional focus during performance because they were dependent on the ball movement. It might take longer and more practice sessions for novice performers to be able to use the evoked attentional focus in their actual performance especially for a task such as a wall pass which takes under two seconds to accomplish. Other studies (e.g. Ford, Williams & Hodges, 2005) investigated soccer tasks such as dribbling which included a long time continuous skill performance. Other than soccer studies most of attentional focus investigations also researched the effect of directing attention to external as compared in internal cues in continuous tasks such as balancing (Riley et al. 1999), skiing (Wulf &Weigelt, 1997), visual tasks, upper limb suprapostural continuous tasks (Hodges & Franks, 2000) and lifting (Wulf et al., 2004) (for a review look at Wulf & Prinz, 2001).

The closest suprapostural task studied was the investigation of attentional focus on a basketball free throw (Zachry et al., 2005), which has certain differences with the present task. In the above mentioned study players had time to prepare for shooting the ball. In such a task the player will take time to direct his or her attention to the cue they were instructed with beforehand. In the present task; however, the participant is completely dependent on the ball movement (outside cue). To put it another way participants would have to adjust their reaction to the ball coming at them to produce the appropriate response. The ballistic nature of this task reduced the time available for focusing on participants' specific action (internal cue) or effect (external cue). Zachry et al's investigation included a closed motor skill in which participants had a predictable task to perform unlike in this study in which, participants performed an open skill and had to respond to the environment and intercept the ball. Soccer investigation by Ford, Williams & Hodges (2005) also investigated a continuous task of dribbling and running. The dribbling task's duration depends on the pace each participant takes to accomplish it. The mentioned experiment included a closed task with predictable environment which makes it different form the preset study.

It should also be noted that unlike many other studies all of the instructions, trials and tests were performed in a single session. As it goes with the short time that was needed for performing the task itself, it is still considerable and might have affected the results of the study. Wulf et al (2003) had participants performing the dual task in practice, retention and test sessions. Wulf, Lauterbach and Toole (1998) also had practice, retention and test trials with several blocks of 10 trials in each session. Wulf and Weigelt (1997) had their participants perform the skiing task in 3 different days. In interpreting no significant effect of attentional focus on relative timing it should be noted that significant differences found in single session tasks were mostly at neuromuscular level for example different EMG activity across conditions of attentional focus was reported by Zachry et al. (2005) on a basketball free throw. Accuracy scores were also affected by attentional condition in above mentioned study and participants could activate their muscle units under no time constrain. Differences in EMG activity levels were also reported in Vance et al. 2004 on a biceps curl task. Relative timing might not be different for attentional focus conditions since it is dependent on the speed of the ball coming at the participant. It should also be considered that in most of the gait and postural tasks, the main effects of attentional focus were reported on daily living tasks such as balancing (e.g. Wulf et al 2003), and did not introduce participants to new unfamiliar tasks. In probe reaction time task (Wulf, McNecvin & Shea, 2001) participants were also dependent on the signal to respond and react; however, again the level of the complexity of the task is incomparable.

The frequency of giving instructions should also be considered when comparing this study to previous research. Because of the discrete nature of the task it seemed mentioning and reminding the cue of attention after each trial could be distractive. The instructions were given to participants by the instruction video, once before the beginning of baseline trials, once before the beginning of the recorded trials and once on the mid trial. This amount of intervention is low compared to previous research. This frequency is in alignment with the fast nature of the task and was used in order to prevent any distractions by letting participants keep their focus on the cue that they were instructed with; however, a certain higher frequency of interventions might have led to significant effect of practice.

Conclusion

The results of this study failed to replicate the findings of previous attentional focus studies. The lack of experience by the participants and time-dependent nature of the task potentially undermined the effect of attentional focus instructions on performance accuracy. However, there was a significant effect of attentional focus instructions on VE data suggesting any attentional focus will benefit consistency. Several factors impacted the ability to identify attentional focus benefits in this study. First, the amount of practice might not have been sufficient to allow attentional focus benefits to emerge. Second, the short duration of each trial might not have allowed sufficient time for participants to use the attentional focus cues effectively while performing the task. Future studies should follow the established pathway of attentional focus on continuous tasks. It is also suggested that future studies might have to test participants with more trials and even more than one session of practice and assess the effect of attentional focus on multiple practice and retention sessions.

This study was the first study to investigate the influence of attentional focus on a discrete pedal suprapostural task; the present results do not replicate previous findings that demonstrated a beneficial effect of adopting an external focus of attention. Although the effect of attentional focus conditions was confounded by short practice session and the rate of interventions also the fact that the task was an open motor task. Present results suggest planned assignment of male and female participants for equal distribution across attentional focus conditions for future research especially in a population who have never performed a similar task before.

Overall the results of this thesis are not in complete agreement with previous research investigating the effect of attentional focus on different motor skills. From all independent variables only VE data was affected by attentional focus and post hoc tests were unable to discriminate between conditions. The above mentioned conditions could not be incorporated as an independent variable for CE, AE and RT. These results are assumed to be due to lack of enough practice. Longer and multiple practice sessions with more trials and more frequent instructions given to participants are suggested for future study in this field. The results of this study are suggestive of certain requirements for the given discrete task to represent effects of attentional focus.

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