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Experience level influences the effect of attentional focus on sprint performance

Nicklaas C. Winkelman [a,*], Kenneth P. Clark [b,c], Larry J. Ryan [b]

[a] Rocky Mountain University of Health Professions, 122 E 1700 S, Provo, UT 84606, USA
[b] Southern Methodist University, 5538 Dyer St., Suite 105, Dallas, TX 75206, USA
[c] West Chester University, 206 Sturzbecker Health Sciences Center, West Chester, PA 19383, USA

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ABSTRACT

Two experiments evaluated the influence of attentional focus on 10-meter sprint time and start kinetics in a group of collegiate soccer players and highly experienced sprinters. In Experiment 1, the collegiate soccer players were asked to perform 10-meter sprints under an external focus condition, an internal focus condition and a control condition. For the 10-meter sprint time, the results showed that both the external focus and control conditions resulted in significantly faster sprint times than the internal focus condition. There were no significant differences observed between the external focus and control conditions. There were also no significant differences observed across any of the conditions for a select set of kinetic variables. In Experiment 2, the highly experienced sprinters performed the same 10-meter sprint task using the same instructional conditions as in Experiment 1. For the 10-meter sprint time and kinetic variables, there were no significant differences observed across any of the conditions. These results provide new evidence that experience level mediates the influence of attentional focus on sprint performance.

1. Introduction

Attentional focus has emerged as an important mediator of performance and learning across a diversity of motor skills (for a review, see Wulf, 2013). Attentional focus is defined by the conscious intent of an individual to direct their attention towards specific features of the environment, or to the action-preparation process, in an effort to execute a motor skill with superior performance (Magill, 2011). Specifically, an individual can focus *internally* on their body movements (i.e., movement process) or *externally* on the effect their movements have on the environment (i.e., movement outcome) (Wulf, Hoss, & Prinz, 1998). For example, a coach instructing the vertical jump may provide an internal cue by telling an athlete to "focus on explosively extending your hips" or provide an external cue by telling an athlete to "focus on explosively pushing off the ground." While the instructions carry the same message (i.e., get off the ground 'explosively'), the internal cue calls attention to the body (i.e., hips) and the external cue calls attention to the effect on the environment (i.e., ground).

The need for coaches and clinical practitioners to optimize verbal instruction and cue selection has motivated numerous investigations into the effects of attentional focus on various motor tasks. The majority of studies evaluating the effects of attentional focus have found that an external focus of attention results in superior performance and learning compared to

* Corresponding author at: Irish Rugby Football Union, 10-12 Lansdowne Road, Ballsbridge, Dublin 4, Ireland.
E-mail addresses: Nick.Winkelman@irfu.ie (N.C. Winkelman), kpclark@mail.smu.edu, kclark@wcupa.edu (K.P. Clark), lryan@mail.smu.edu (L.J. Ryan).

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an internal focus (for reviews, see Marchant, 2011; Wulf, 2013). For example, Wulf et al. (1998) (experiment 1) found that instruction inducing an external focus of attention, rather than an internal focus of attention, led to better performance and learning on a ski-simulator task in novice participants. The internal focus group was "instructed to exert force on the outer *foot*" and the external focus group was "instructed to exert force on the outer *wheels*," while a control group received no explicit instruction. The results showed that the external focus group was significantly more effective than the internal focus group during practice (i.e., greater amplitude and frequency of movement). More importantly, the external focus group was significantly more effective than the internal focus and control groups during a delayed retention test – where no instruction was given, which provides evidence that an external focus leads to superior skill learning than an internal focus or no focus at all. There has since been extensive research confirming the performance and learning benefits of an external focus of attention for balance and supra-postural tasks (e.g., McNevin, Shea, & Wulf, 2003; Wulf, Weigelt, Poulter, & McNevin, 2003), vertical and horizontal jumping (e.g., Porter, Ostrowski, Nolan, & Wu, 2010; Wulf, Zachry, Granados, & Dufek, 2007), agility (e.g., Porter, Nolan, Ostrowski, & Wulf, 2010), sprinting (e.g., Ille, Selin, Do, & Thon, 2013; Porter, Wu, Crossley, & Knopp, 2015), swimming (e.g., Freudenheim, Wulf, Madureira, Pasetto, & Corrêa, 2010; Stoate & Wulf, 2011), and a diversity of sport specific skills (e.g., Al-Abood, Bennett, Hernandez, Ashford, & Davids, 2002; Wulf, McNevin, Fuchs, Ritter, & Toole, 2000).

The 'constrained action hypothesis' has been proposed as a theoretical explanation for the learning and performance advantage of adopting an external focus rather than an internal focus of attention (Wulf, McNevin, & Shea, 2001). Accordingly, Wulf et al. (2001) suggest that an internal focus "constrains the motor system by interfering with automatic motor control processes that would 'normally' regulate the movement;" conversely, an external focus allows the "motor system to more naturally self-organize, unconstrained by the interference caused by conscious control attempts" (p. 1144). Further, Wulf and Lewthwaite (2010) suppose that an internal focus of attention causes a "self-invoking trigger," which leads to overt control over movements that would otherwise be controlled automatically, causing a series of ongoing "microchoking" episodes. From a motor control perspective, Lohse, Jones, Healy, and Sherwood (2014) have provided empirical evidence for this, showing that individuals adopt different control strategies under an internal and external focus of attention (Lohse, Sherwood, & Healy, 2010). Specifically, Lohse and colleagues (Lohse et al., 2010, 2014) evaluated novices learning a dart-throwing task and found that an external focus of attention resulted in greater kinematic variability in the throwing arm, with a concomitant increase in accuracy. Conversely, an internal focus of attention resulted in reduced kinematic variability in the throwing arm, with a similar reduction in accuracy. The researchers suggest that adopting an external focus of attention leads to increased "functional variability" (Muller & Loosch, 1999), allowing the motor system to reduce variability in the target outcome (i.e., accuracy) by increasing movement variability in redundant bodily dimensions (e.g., joint motion), and therefore increase the number of coordinative solutions available to achieve the desired outcome.

Although research has highlighted the beneficial effects of adopting an external focus of attention (Wulf, 2013), the majority of studies have examined motor skill performance (e.g., balance control, golf shot accuracy, and jump height) without investigating the biomechanical factors underpinning performance changes (Lohse et al., 2010). The few studies that have examined the effects of attentional focus on the mechanical determinants of movement performance have primarily evaluated implement-based skills including juggling (Zentgraf & Munzert, 2009), rowing (Parr & Button, 2009), dart throwing (Lohse et al., 2010, 2014), and golf (An, Wulf, & Kim, 2013; Lawrence, Gottwald, Khan, & Kramer, 2012; Munzert, Maurer, & Reiser, 2014). However, there are limited and inconsistent findings surrounding the influence of attentional focus on the biomechanical factors that may underpin focus mediated performance differences in non-implement based skills (e.g., sprinting, jumping, and agility). For example, Wulf and Dufek (2009) found that physically active students generated significantly larger vertical impulse during a vertical jump when focusing externally opposed to internally. In agreeance with Wulf and Dufek (2009), Wu, Porter, and Brown (2012) and Ducharme, Wu, Lim, Porter, and Geraldo (2016) found that university students broad jumped significantly farther using an external focus condition compared to an internal focus condition, however, the differences observed in performance were not explained by differences in peak force (Ducharme et al., 2016; Wu et al., 2012) or impulse (Ducharme et al., 2016). More recently, Bezodis, North, and Razavet (2016) found that college aged team sport athletes sprinted over 10-meters significantly faster under a control condition (i.e., no explicit focus) compared to an internal focus condition and external focus condition, which were not different from one another. From a kinetics standpoint, the control condition generated less peak vertical force and vertical impulse compared to the other conditions, however, no other kinetic variables (e.g., average horizontal force) were shown to be different across the three conditions. Thus, building on the research noted above, it is of scientific and practical importance to gain further insight into the influence of attentional focus on biomechanical determinants of performance in non-implement based motor skills.

Among non-implement based motor skills, the ability to accelerate rapidly is of particular interest because of the broad application to a variety of sports (e.g., Di Salvo et al., 2010; Duthie, Pyne, Marsh, & Hooper, 2006; Lockie, Murphy, Schultz, Jeffriess, & Callaghan, 2013). Thus, expanding on the work of Bezodis et al. (2016), the first aim of this study was to evaluate the differential effects of various attentional focus instructions (i.e., internal focus, external focus and 'normal focus') on 10-meter sprint performance and a select set of kinetic variables. Specifically, while multiple studies have assessed the influence of attentional focus on sprint performance (Bezodis et al., 2016; Ille et al., 2013; Mallett & Hanrahan, 1997; Porter & Sims, 2013; Porter et al., 2015), and while Bezodis et al. (2016) also evaluated step kinetics & kinematics at 5-meters, no research has evaluated the role of start kinetics in explaining sprint performance differences influenced by various attentional foci. Based on the evidence showing the importance of mass-specific horizontal propulsive force during the start of a sprint (Clark & Weyand, 2015; Morin et al., 2012; Rabita et al., 2015), in addition to capturing 10-meter sprint times (s), the present study assessed start kinetics by evaluating average total force (TFavg), average vertical force (VFavg), and average horizontal force (HFavg) all normalized to body weight (i.e., BWs). This approach aimed to provide a more detailed analysis of kinetics, while increasing the resolution on force specific variables that may be associated with performance across attentional focus conditions.

The second aim of this study was to evaluate the role of experience level in mediating the influence of attentional focus on sprint performance. Specifically, two experiments were performed to examine the differential impact of instruction on 10-meter sprint performance in a group of soccer players who were considered moderately experienced at sprinting (Experiment 1) and a group of sprinters who were considered highly experienced at sprinting (Experiment 2). Research has shown that both those with limited to no sprint experience and those highly experienced at sprinting benefit from adopting an external focus opposed to an internal focus of attention (Ille et al., 2013; Mallett & Hanrahan, 1997; Porter et al., 2015; Wulf, McConnel, Gartner, & Schwarz, 2002; Wulf & Su, 2007). However, some research has also shown that those with a moderate to high level of task experience perform equally well (Stoate & Wulf, 2011) or better (Bezodis et al., 2016; Porter & Sims, 2013; Wulf, 2008) when no explicit focus is provided (i.e., control condition or 'normal focus'). Thus, there is still uncertainty surrounding the differential influence of attentional focus on performance and learning in those with different levels of experience.

Based on the research noted above, it was hypothesized that instruction leading to an external focus of attention, rather than an internal focus, would result in the fastest 10-meter sprint times within a population of collegiate soccer players (Experiment 1) and a population of sprinters (Experiment 2). It was also hypothesized that a control condition would result in a faster 10-meter sprint time than an internal focus condition in the sprinters (Experiment 2). Finally, it was hypothesized that any differences observed between the attentional focus conditions would be explained by differences in the kinetic variables, namely an increase in mass-specific horizontal force.

2. Experiment 1

As mentioned above, studies on sprinting have shown that those with no experience and those that are highly experienced benefit from adopting an external focus of attention (Ille et al., 2013; Mallett & Hanrahan, 1997; Porter et al., 2015). However, the findings by Porter and Sims (2013), and more recently by Bezodis et al. (2016), suggest that the benefit of an external focus may be influenced by the experience level of the participant (Stoate & Wulf, 2011; Wulf, 2008). Moreover, no study has evaluated how attentional focus influences the start kinetics associated with 10-meter sprint performance. Therefore, Experiment 1 evaluated how instructions encouraging an internal focus, external focus or a 'normal focus' (i.e., control condition) influenced start kinetics and 10-meter sprint performance in a group of collegiate soccer players. This population can be considered moderately experienced, as their sport requires a significant amount of sprinting; however, they are not likely to be considered highly experienced, as they do not explicitly focus on optimizing sprint technique in an effort to maximize sprint performance.

2.1. Methods

2.1.1. Participants

Seventeen healthy, male collegiate soccer players, with a mean age of 19.41 years (*SD*: 1.06), participated in the study. Participants had a mean height of 1.77 m (*SD*: 0.07) and a mean body mass of 73.30 kg (*SD*: 7.94). Participants were recruited based on their experience performing repeated short sprints in the context of a competitive soccer program (Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009) and their familiarity with the two-point starting position that is common to sprint testing in soccer (Little & Williams, 2005). All participants were considered to be moderately experienced at sprinting, with no participants being considered highly experienced. That is, while all of the participants have experience sprinting (i.e., 10-meters), they do not have experience practicing and competing in a track and field context. This means the participants' experience level, while extensive, would not be as high as an individual who purely trained and competed in the sport of sprinting (i.e., highly experienced sprinter), further supporting why the participants are classified as moderately experienced (Swann, Moran, & Piggott, 2015). All participants completed a medical history questionnaire and informed consent prior to the experiment. The University's Institutional Review Board approved all forms and experimental procedures. Participants were naïve to the purpose of the study.

2.1.2. Apparatus and task

The task used in this study was a maximal effort 10-meter sprint from a motionless two-point (upright) start position with the feet staggered and preferred foot forward. The 10-meter sprint distance was selected for two primary reasons. First, it is common for soccer players to perform sprints between 10-meters and 20-meters in the context of competition (Di Salvo et al., 2009). Second, the attentional focus cues provided were selected to encourage technical characteristics associated with acceleration as opposed to maximal velocity. Thus, 10-meters was identified as an appropriate distance to assess acceleration ability, with longer distances (e.g., 20-meters) being better suited to assess maximal velocity sprint performance (Little & Williams, 2005). All sprints took place within a closed lab setting that had a 1-meter wide running lane positioned within 20-meters of linear running space. Participants were required to sprint over 2.7-meters of force platform before transitioning to a seamless rubber flooring that extended the entire length of the sprint. Time was recorded for the 0–10 m split. After completing the 10-meter sprint, participants had an additional 10-meters to decelerate, with a crash mat (0.30 m × 1.22 m × 2.44 m) set at the end of the runway for safety. Timing data were collected using a custom dual-beam laser timing system (Banner Engineering, Model #QS186LE Laser Emitters and Model #QS18 Receivers), which sampled at 1000 Hz and had 0.750 ms response time. The dual-beam design has been shown to improve timing accuracy, as participants must simultaneously block both lasers before the split is calculated. This minimizes timing error due to variation in sprint technique, as the trunk is the only aspect of the participant's body that will always block both beams (Earp & Newton, 2012). Lasers were set 10-meters from the start line, with the upper and lower lasers stacked vertically at 115 cm and 85 cm from the ground, respectively.

Kinetic data were obtained using three integrated force platforms (Bertec, Model #FP9090-15-4000, 0.9 × 0.9 m). Timing data and kinetic data were synchronized through National Instruments PCIe-6323 data acquisition board (32 analog inputs, 250 kS/s, 16-bit resolution) and LabVIEW (2011) software, sampling at 1000 Hz. The force data was post-filtered using a low-pass, fourth-order, zero-phase-shift Butterworth filter with a cutoff frequency of 25 Hz. To minimize timing error due to variations in two-point start technique (e.g., bouncing, false step, etc.), a start trigger was designed using the force platform. Specifically, timing started once the participant generated 150 N of horizontal force (Fy Trigger).

2.2. Procedure

Participants completed 2 × 10-meter sprints under an internal focus, an external focus and a control condition with no explicit focus (i.e., 'normal focus'), for a total of six 10-meter sprints. All conditions were counterbalanced and randomly assigned, with a total of six possible condition orders. Thus, all three conditions (i.e., internal focus, external focus and 'normal focus') were equally balanced across the three sets of 2 × 10-meter sprints, meaning, participants were equally likely to perform any of the conditions during their first, second or third set of sprints. Participants were given two minutes rest between repetitions and four minutes rest between conditions to avoid the effects of fatigue. To standardize all clothing and footwear, each participant was outfitted with an appropriately sized pair of rubber track flats, a long-sleeve black compression shirt, and black compression pants. Participants then performed a 10-min standardized dynamic warm-up that was facilitated by a Certified Strength and Conditioning Specialist (CSCS). As a part of the dynamic warm-up, participants were instructed on general set-up guidelines (i.e., foot placement, body position, and arm position) for the two-point start. Participants were specifically given the following general set-up instructions: "Stand at the start line with your feet hip width apart. Get into your typical 2-point stance by placing one foot behind the start line and placing your other foot back at a comfortable distance. Set your arms so that they are positioned opposite from your legs. Load into your legs and shift forward so that you feel tension and a readiness to sprint forward with no delay." Note that the researcher provided a general demonstration with the 2-point start instruction in an effort to reduce any confusion, however, this demonstration was only done once. Participants were then allowed to perform two sub-maximal repetitions over 5-meters and one maximal repetition over 10-meters to familiarize them with the testing protocol. After completing the warm-up, participants were given the following general instructions: "The remaining six sprints will be completed as fast as you can at 100% of your full speed. Prior to each sprint you will be given a specific focus cue. Focus as hard as you can on this cue during the entire sprint." During the six sprints that followed, participants received specific focus instructions prior to getting into their two-point stance and received a reminder of their focus before sprinting when they were ready. During the control condition, participants were told to "focus on performing the task to the best of your ability" and reminded to "perform to the best of your ability" prior to sprinting. During the internal focus condition, participants were told to "focus on driving your legs back as explosively as you can" and reminded to "drive your legs back explosively" prior to sprinting, whereas during the external focus condition, participants were told to "focus on driving the ground back as explosively as you can" and reminded to "drive the ground back explosively" prior to each sprint. All instructions were delivered by a CSCS certified strength & conditioning coach with 10 years of experience working with athletes on speed development. Moreover, all instructions were read from a seated position that was 4 feet to the left of the start line where the participants stood. Note that the focus cues were selected based on their relevance to known biomechanical features associated with successful sprint performance, namely mass-specific force application (Clark & Weyand, 2014; Morin et al., 2012; Rabita et al., 2015; Weyand, Sandell, Prime, & Bundle, 2010; Weyand, Sternlight, Bellizzi, & Wright, 2000). Specifically, basic physics dictates that enough vertical force must be applied during each step to support and lift the center of mass, and assuming this requirement is met, forward acceleration is directly linked to the amount of force and impulse (relative to body mass) that the runner applies backwards (i.e., horizontally) (Clark & Weyand, 2015). Consistent with these fundamental Newtonian mechanics, several recent studies have found that acceleration ability has been correlated with mass-specific horizontal propulsive force during the initial steps of the sprint (Clark & Weyand, 2015; Kawamori, Newton, & Nosaka, 2014; Kugler & Janshen, 2010; Morin et al., 2012; Rabita et al., 2015). Therefore, the focus cues selected were designed to encourage horizontal force production. Additionally, experienced sprint coaches and sprinters confirmed that the focus cues selected had practical validity. Moreover, the internal and external focus cues were matched for content and quantity, with the only difference being the "leg" reference in the internal focus cue and the "ground" reference in the external focus cue.

2.3. Dependent variables and data analysis

Timing data was averaged across the two trials within each condition, providing a single 10-meter sprint time for each condition. During each sprint, time started once the participant generated 150 N of horizontal force at the start, and time was recorded at 10-meters when both beams of the laser timing system were crossed. Kinetic data was captured throughout the two-point start during each sprint. Data was only analyzed for the two-point start due to variation in how many steps were recorded on the platform between participants. The outcomes analyzed included: average total force normalized to body mass (TFavg), average vertical force normalized to body mass (VFavg), and average horizontal force normalized to body mass (HFavg). To examine the effect of attentional focus on the kinetic factors across conditions, the kinetic variables were averaged across the two sprint trials within each condition.

A Shapiro-Wilk analysis was used to assess the normality of all data sets to be statistically analyzed (Ghasemi & Zahediasl, 2012). Under conditions of normality, data were analyzed using one-way repeated measures ANOVAs with a Bonferroni *post hoc* to assess significant differences. To assess the assumption of sphericity, Mauchly's test of sphericity was conducted prior to all *post hoc* analyses. If sphericity was violated, the adjusted degrees of freedom and significance values were used based on a Greenhouse-Geisser correction. Under conditions where the assumption of normality was violated, data were analyzed using the Friedman test with a Wilcoxon signed-rank *post hoc* to assess significant differences. The partial eta squared (η_p^2) effect size statistic was calculated to determine the magnitude of observed differences. Effect sizes were based on the criteria of $\eta_p^2 < 0.01$, small; $\eta_p^2 = 0.06$, moderate; and $\eta_p^2 > 0.14$, large. The Cohen's d effect size statistic was used to measure the magnitude of difference between group means. The magnitude of Cohen's d corresponded to low (d = 0.2), medium (d = 0.5), and large (d = 0.8) effects (Cohen, 1988). The Statistical Package for the Social Sciences (SPSS) version 24 was used for all data analysis.

2.4. Results

2.4.1. Timing data

Seventeen participants were originally tested in this experiment; however, data from one of the participants was removed because they were unable to correctly execute a two-point start from a motionless stance. Table 1 presents the mean 10-meter sprint times for all three conditions. The 10-meter time data was confirmed for normality and did not violate Mauchly's test of sphericity ($p = 0.071$). The results for 10-meter time indicated significant differences between focus conditions, $F(2, 28) = 5.131$, $p = 0.013$, $\eta_p^2 = 0.268$. A Bonferroni *post hoc* revealed that both the control ($p = 0.021$, $d = -0.287$) and external focus conditions ($p = 0.002$, $d = -0.226$) were significantly faster than the internal focus condition, with no difference between the control and external focus conditions ($p = 1.0$, $d = 0.064$). Further analysis revealed that the interaction between attentional focus condition and condition order was not significant, $F(2, 28) = 2.230$, $p = 0.126$, $\eta_p^2 = 0.137$. Paired-Samples T-Tests were used to assess any differences between trials, independent of condition order, to rule out the impact of fatigue across the six trials. The results revealed no statistical difference between trial 1 and trial 2 ($p = 0.644$), trial 1 and trial 3 ($p = 0.479$), trial 1 and trial 4 ($p = 0.408$), trial 1 and trial 5 ($p = 0.247$), and trial 1 and trial 6 ($p = 0.057$).

2.4.2. Kinetic data

The TFavg violated the assumption of normality; therefore, the Friedman test was used to evaluate significance. The results of the Friedman test indicated no difference between conditions for TFavg, $\chi^2(2) = 1.500$, $p = 0.472$. Table 2 presents the mean force and standard deviations normalized to body weight for TFavg.

The VFavg violated the assumption of normality; therefore, the Friedman test was used to evaluate significance. The results of the Friedman test indicated no difference between conditions for VFavg, $\chi^2(2) = 1.500$, $p = 0.472$. Table 3 presents the mean force and standard deviations normalized to body weight for VFavg.

The HFavg data was confirmed for normality and did not violate Mauchly's test of sphericity ($p = 0.659$). The results of the ANOVA indicated no difference between conditions for HFavg $F(2, 30) = 2.903$, $p = 0.070$, $\eta_p^2 = 0.162$. Table 4 presents the mean force and standard deviations normalized to body weight for HFavg.

2.5. Discussion

The purpose of Experiment 1 was to evaluate how different attentional foci influenced start kinetics and 10-meter sprint performance in a group of collegiate soccer players. Similar to previous findings on sprint performance, the external focus condition resulted in significantly faster sprint times than the internal focus condition (Ille et al., 2013; Porter et al.,

Table 1
Mean 10-meter sprint times (s) across external focus, internal focus and control conditions for Experiments 1 and 2 (*SD* in parentheses).

	External Focus Condition	Internal Focus Condition	Control Condition
Soccer Players (Experiment 1)	2.147 (0.077)	2.165 (0.082)	2.142 (0.078)
Sprinters (Experiment 2)	2.117 (0.100)	2.109 (0.107)	2.109 (0.085)

Table 2
Mean Total Force (BWs) across external focus, internal focus and control conditions for Experiments 1 and 2 (*SD* in parentheses).

	External Focus Condition	Internal Focus Condition	Control Condition
Soccer Players (Experiment 1)	1.27 (0.07)	1.27 (0.06)	1.27 (0.06)
Sprinters (Experiment 2)	1.30 (0.10)	1.33 (0.10)	1.31 (0.07)

Table 3
Mean Vertical Force (BWs) across external focus, internal focus and control conditions for Experiments 1 and 2 (*SD* in parentheses).

	External Focus Condition	Internal Focus Condition	Control Condition
Soccer Players (Experiment 1)	1.12 (0.05)	1.12 (0.04)	1.12 (0.04)
Sprinters (Experiment 2)	1.14 (0.07)	1.16 (0.07)	1.14 (0.05)

Table 4
Mean Horizontal Force (BWs) across external focus, internal focus and control conditions for Experiments 1 and 2 (*SD* in parentheses).

	External Focus Condition	Internal Focus Condition	Control Condition
Soccer Players (Experiment 1)	0.61 (0.06)	0.60 (0.05)	0.61 (0.05)
Sprinters (Experiment 2)	0.62 (0.07)	0.64 (0.08)	0.63 (0.06)

2015). However, the external focus condition resulted in similar sprint times to the control condition, which has also been reported in a study evaluating swimming (Stoate & Wulf, 2011). This finding supports the existing evidence showing that an external focus of attention improves performance relative to an internal focus of attention (Wulf, 2013), while providing further support that those with a moderate to high level of task experience demonstrate performance decrements under an internal focus of attention relative to a control condition (Porter & Sims, 2013; Stoate & Wulf, 2011; Wulf, 2008). While this result is in support of the hypothesis for Experiment 1, it was not hypothesized that the control condition would result in similar sprint times as the external focus condition. Interestingly, this was the hypothesis for Experiment 2, as research has shown that individuals with a high level of task experience perform equally well (Stoate & Wulf, 2011) or better (Wulf, 2008) when no explicit focus is provided (i.e., control condition) compared to an external focus of attention. Therefore, Experiment 1 seems to provide evidence that it is not only highly experienced individuals, but also those with a moderate level of task experience, that demonstrate better performance under both external and normal focus conditions as compared to an internal focus of attention.

While an external focus and normal focus resulted in faster 10-meter sprint times than an internal focus, this result cannot be explained by differences in average force during the start, as the present study found no difference between attentional focus conditions for TFavg, VFavg, and HFavg. These results are in direct contrast to the proposed hypothesis that any sprint performance differences observed across attentional focus conditions would be associated with differences in kinetic outcomes. Additionally, it is surprising that HFavg was not significantly different across attentional focus conditions considering the evidence showing the importance of mass-specific horizontal propulsive force during the start of a sprint (Clark & Weyand, 2015; Morin et al., 2012; Rabita et al., 2015). However, while this is the first study to evaluate the influence of attentional focus on the start kinetics associated with 10-meter sprint performance, similar findings have been reported elsewhere. For example, research has shown that while an external focus leads to improved vertical (Talpey, Young, & Beseler, 2016) and horizontal (Wu et al., 2012) jump performance, kinetic mechanisms (i.e., peak force) could not explain the differences observed in the attentional focus conditions. Specifically, Talpey et al. (2016) found that an internal focus of attention yielded a higher peak force and a lower vertical jump height than an external focus. Conversely, Wu et al. (2012) found no difference in peak force between internal and external focus conditions; however, the external focus condition resulted in significantly farther horizontal jump distances. More recently, Bezodis et al. (2016) found that a group of team sport athletes produced more peak vertical force at 5-meters under internal focus and external focus conditions compared to a control condition when performing a 10-meter sprint. Similar to Porter and Sims (2013), Bezodis et al. (2016) also found that the participants ran faster under the control condition compared to the internal and external focus conditions, which were not different from one another. Thus, the link between attentional focus and the resulting kinetic outcomes needs further examination, as the amount of evidence is limited and the substance of the findings are inconsistent.

3. Experiment 2

Experiment 2 used the same design as Experiment 1; however, a group of highly experienced sprinters were recruited to participate in the study. While research has evaluated the influence of attentional focus on sprint performance in highly experienced sprinters (Ille et al., 2013; Mallett & Hanrahan, 1997), there are obvious differences between the instructional approaches used in these studies and the present one. For example, Ille et al. (2013) had two methodological issues that were overcome in the design used within Experiment 2. First, Ille et al. (2013) used internal (i.e., "push quickly on your legs and keep going as fast as possible while swinging both arms back and forth and raising rapidly your knees") and external focus (i.e., "get off the starting blocks as quickly as possible, head towards the finish line rapidly and cross it as soon as possible") instructions that were not matched for content and required participants to adopt multiple foci. Wulf (2013) has argued that to directly compare an internal focus to an external focus, and "ensure there are no potential confounding factors, instructions [should be] comparable in wording and information content" (p. 19). Moreover, it has been shown that explicit rule build-up can negatively impact skill learning (Poolton, Maxwell, Masters, & Raab, 2006), therefore, one explanation for the results observed in Ille et al. (2013) would be that the internal focus condition required more conscious processing (i.e., internal focus condition had four different instructional elements) than the external focus condition (i.e., external focus condition had two to three instructional elements), which reduced the amount of attentional resources that could be applied to the task (i.e., 10-meter sprint) itself. The second methodological issue with Ille et al. (2013) is that they did not counterbalance the control condition with the internal and external focus conditions. Therefore, no conclusions can be made about the potential benefit of a control condition relative to an internal and external focus of attention. As described in Experiment 1, the present study overcomes theses methodological issues by using focus cues that were matched for informational content and quantity. Additionally, the external focus condition, internal focus condition and control condition were counterbalanced in an effort to remove order effects and provide insights into how a 'normal focus' condition (i.e., control) would influence performance in highly experienced sprinters.

3.1. Methods

3.1.1. Participants

Highly experienced sprinters (N = 13; 6 females, 7 males), with a mean age of 28 years (*SD*: 4.32), were recruited to participate in this study. Participants had a mean height of 1.73 m (*SD*: 0.06) and a mean body mass of 73.76 kg (*SD*: 10.70). All participants had high school and collegiate track and field experience (i.e., $\geqslant$ 8 years), and were currently in a sprint-trained state (i.e., competing recreationally or professionally). Thus, the participants have accumulated a high level of practice and competitive experience performing and focusing on maximal effort sprinting with the intention to optimize technical efficiency (Swann et al., 2015). All participants completed a medical history questionnaire and informed consent prior to the experiment. The University's Institutional Review Board approved all forms and experimental procedures. Participants were naïve to the purpose of the study.

3.1.2. Apparatus, task and procedure

The apparatus task and procedure used in Experiment 2 were the same as Experiment 1.

3.1.3. Dependent variables and data analysis

The dependent variables and data analysis used in Experiment 2 were the same as Experiment 1.

3.2. Results

3.2.1. Timing data

The 10-meter time data was confirmed for normality and did not violate Mauchly's test of sphericity ($p = 0.616$). The results for 10 m time indicated no significant differences between focus conditions, $F(2, 22) = 1.672$, $p = 0.211$, $\eta_p^2 = 0.132$. Table 1 presents the mean 10-meter sprint times for all three conditions. Further analysis revealed that the interaction between attentional focus condition and condition order was not significant, $F(2, 22) = 2.204$, $p = 0.134$, $\eta_p^2 = 0.167$. Paired-Samples T-Tests were used to assess any differences between trials, independent of condition order, to rule out the impact of fatigue across the six trials. The results revealed no statistical difference between trial 1 and trial 2 ($p = 0.879$), trial 1 and trial 3 ($p = 0.583$), trial 1 and trial 4 ($p = 0.264$), trial 1 and trial 5 ($p = 0.412$), trial 1 and trial 6 ($p = 0.494$).

3.2.2. Kinetic data

The results of the Friedman test indicated no difference between conditions for TFavg, $\chi^2(2) = 3.231$, $p = 0.199$. Table 2 presents the mean force and standard deviations normalized to body weight for TFavg.

The results of the Friedman test indicated no difference between conditions for VFavg, $\chi^2(2) = 2.923$, $p = 0.232$. Table 3 presents the mean force and standard deviations normalized to body weight for VFavg.

The HFavg data was confirmed for normality and did not violate Mauchly's test of sphericity ($p = 0.415$). The results of the ANOVA indicated no difference between conditions for HFavg $F(2, 24) = 1.614$, $p = 0.220$, $\eta_p^2 = 0.119$. Table 4 presents the mean force and standard deviations normalized to body weight for HFavg.

3.3. Discussion

The purpose of Experiment 2 was to evaluate how different attentional foci influenced start kinetics and 10-meter sprint performance in a group of highly experienced sprinters. Contrary to the findings of Experiment 1, and previous research (Ille et al., 2013; Mallett & Hanrahan, 1997; Porter & Sims, 2013; Porter et al., 2015), the results showed no differences in 10-

meter sprint times across the external focus, internal focus and control conditions. It is worth noting that Porter and Sims (2013) found the same result within a group of collegiate football players. Specifically, they found no difference in 0–10 yard and 0–20 yard sprint times across external focus, internal focus and control conditions; however, as they emphasize in their discussion, they did find that the 'normal focus' control condition resulted in faster sprint times from 10 to 20 yards than both the external focus and internal focus conditions, which were not different from one another. While the authors conclude that "coaches should issue instructions that do not promote a skill-focused attention" (Porter & Sims, 2013, p. 49), and note similar findings within highly experienced acrobats performing a balance task (Wulf, 2008), the results in the present study do not support this conclusion. Moreover, the results of Experiment 2 do not support the hypotheses that both an external focus and a 'normal focus' (i.e., control condition) would result in faster 10-meter sprint times than an internal focus of attention. Theoretical rationale and practical implications are discussed in the general discussion section.

Similar to Experiment 1, the results of Experiment 2 showed no difference between attentional focus conditions for TFavg, VFavg, and HFavg. While the hypothesis that any differences in sprint time would be associated with differences in kinetic outcomes was confirmed, this result should be evaluated in light of Experiment 1 showing that the differences in sprint time were not associated with concomitant differences in the select set of kinetic variables. Thus, more research is required to understand the role of kinetic outcomes in explaining performance differences elicited by various attentional foci.

4. General discussion

To test the aims of this dual experiment study, participants were asked to perform 2 × 10-meter sprint trials under an internal focus, external focus and a control condition with no explicit focus (i.e., 'normal focus'). Force data was collected during the first 2.7 m of the sprint and time data was collected for the 0–10 m split. This protocol is similar to previous studies that evaluated sprint performance and attentional focus using a within-subject design (Bezodis et al., 2016; Porter & Sims, 2013; Porter et al., 2015); however, this is the first study to also evaluate kinetic outcomes during sprint start performance. Moreover, the timing system created for this study had an accuracy of 0.00075 s, which decreased the likelihood that group differences were due to variation in the accuracy of the timing system. This is important, as single-beam timing systems with slow sampling frequency, which are commonly use in research evaluating the influence of attentional focus on sprint performance (Bezodis et al., 2016; Porter & Sims, 2013; Porter et al., 2015), can often lead to inconsistencies and poor accuracy of timing (Earp & Newton, 2010, 2012). Further, the use of the 150 N horizontal force threshold as a start trigger decreased the likelihood of timing error due to individual variation in start technique and the variability in timing that can occur with fly-in start distances (Haugen, Tonnessen, & Seiler, 2015)

4.1. Timing data

The hypothesis that an external focus of attention will result in faster 10-meter sprint times than an internal focus of attention was supported by the findings in Experiment 1. However, the results also showed that the control condition with no explicit focus, while not different from the external focus condition, also resulted in faster sprint times than the internal focus condition. This finding generally aligns with the 'constrained action hypothesis' (Wulf et al., 2001) and provides further support for the performance enhancing benefit of an external focus of attention over an internal focus (Wulf, 2013). Moreover, the collegiate soccer players that participated in Experiment 1, while not highly experienced sprinters, can be considered moderately experienced at sprinting, which is likely why they experienced a degradation in performance during the internal focus condition relative to the external focus and control conditions. Furthermore, while it is clear that those with limited to no experience and those that are highly experienced at a given task benefit from instructional cues that encourage an external focus of attention opposed to an internal focus of attention (Wulf, 2013), what has been less clear is the experience threshold with which a control condition encouraging no explicit focus becomes beneficial to the learner. Thus, more research is needed to clearly identify experience level thresholds whereby it is best to use instruction to encourage an external focus, a 'normal focus' or some combination of both.

Contrary to the findings in Experiment 1, Experiment 2 showed no difference in 10-meter sprint performance across the external focus, internal focus and control conditions. Thus, Experiment 2 did not support the hypotheses that both the external focus and control conditions would result in faster 10-meter sprint times than the internal focus condition. This result is surprising, as research has shown that individuals who are highly experienced in a particular task benefit from an external focus (Ille et al., 2013; Mallett & Hanrahan, 1997; Wulf & Su, 2007), their 'normal focus' (i.e., control condition) (Wulf, 2008) or a combination of both (Stoate & Wulf, 2011); however, no studies have shown that highly experienced individuals benefit equally from an internal focus, external focus and their 'normal focus' of attention. While this finding would initially suggest that an internal focus, external focus and 'normal focus' of attention are equally effective for a highly experienced individual performing a continuous skill like sprinting, these results need to be evaluated from the standpoint that experience level likely influences how attentional focus is mediated by the informational properties of the focus cue.

To understand these results, and the role experience level plays in influencing how information is abstracted from attentional focus cues, it is important to examine theories of learning and the associated empirical evidence in support of them. Stage models of motor learning (Anderson, 1982; Fitts, 1964) suggest that individuals move from a cognitive or declarative stage – whereby explicit rules are acquired concerning goal-relevant dimensions of the skill, to an autonomous or procedural stage – whereby goal-relevant dimensions of the skill have been consolidated (Song, 2009) and are no longer consciously attended to during skill performance (Masters, 1992). These models of learning are generally supported by research showing that highly experienced individuals perform better when they focus on relevant or irrelevant features of the environment, while those with limited to no experience benefit from using a skill-focused strategy (Beilock, Carr, MacMahon, & Starkes, 2002; Castaneda & Gray, 2007). Thus, individuals with limited to no experience are actively searching to connect goal-relevant dimensions of the movement to the desired outcome (e.g., accurate golf putt or dribbling a soccer ball). Conversely, the individual with a high experience level has an implicit understanding of the goal-relevant dimensions that lead to the desired movement outcome, and therefore, no longer needs to focus on step-by-step movement execution.

Hence, to understand the results in Experiment 2, it is important to examine how meaning is abstracted from internal and external focus cues, and how this might be mediated by experience level. Abstracting meaning requires the ability to ignore unimportant details contained within information, focus on the important features, and leverage past experiences and knowledge to construct generalized ideas (Vas, Spence, & Chapman, 2015). Recent research (Corbin, Reyna, Weldon, & Brainerd, 2015) suggests that highly experienced individuals extract the general subjective meaning from instructional information, while someone with limited to no experience is more likely to attend to the literal meaning of the instruction being presented. The result of this is that highly experienced individuals may often revert to their 'normal focus', which has been consolidated and automatized over years of practice, leading to superior performance regardless of the type of cue provided. The person with limited to no experience, on the other hand, is not likely to self-select the optimal goal-relevant feature to attend to using their 'normal focus', as their action concepts and perceptual representations of the skill are not yet developed (Schack, 2004), and thus they may suffer the performance decrements commonly associated with internal cues (Wulf et al., 2001).

This theoretical explanation for how information is abstracted from attentional focus cues as a function of experience level can be used to provide a possible explanation for the findings in Experiment 2. Specifically, the participants in Experiment 2 had at least eight years of competitive track and field experience. Therefore, all participants would have had well developed action concepts and perceptual effect representations, meaning they have an implicit understanding of how to effectively perform the motor action, while having a perceptual understanding of what the proper movement action feels like (Schack, 2004). Moreover, all participants would have been very experienced with the internal and external focus cues commonly used to teach sprinting (Porter, Wu, & Partridge, 2010). Thus, it can be assumed that their ability to abstract subjective meaning from any attentional focus cues would have been very high. Based on the attentional focus cues provided (see Methods), it is evident that not one cue can be considered literal, and therefore these highly experienced participants would have been able to abstract subjective meaning based on their familiarity with the sprinting task. Specifically, the control condition would have allowed them to select their 'normal focus', which would have been optimized based on their implicit motor plan for sprinting. Additionally, "driving your legs back" (i.e., internal focus) does not require the participant to focus on any one aspect of the leg (e.g., "extend your knee"), therefore, giving the participant the creative freedom to abstract how they will drive their leg back, which could include a re-interpretation that represents an external focus (e.g., "push back"). Further, "drive the ground back" (i.e., external focus) is similar to the internal focus in that it allows the participant to abstract meaning and apply the cue in the way that makes the most sense to them, as they are not literally able to "drive the ground back." Therefore, the null effect observed in Experiment 2 is possibly a result of the highly experienced participants extracting similar meaning from all attentional focus conditions. In hindsight, this would make sense, as the internal and external focus cues were selected based on their relevance to the most important goal-relevant features of acceleration (Clark & Weyand, 2015; Morin et al., 2012; Rabita et al., 2015), and likely directed attention in a manner similar to the 'normal focus' selected by the participants during the control condition. Further support for this conclusion is provided by research showing that focus cue familiarity is a stronger determinant of performance than direction of attentional focus (i.e., internal versus external) (Maurer & Munzert, 2013). Thus, the focus cues selected were confirmed for practical validity through conversations with highly experienced sprint coaches and sprinters, therefore, it is likely that the highly experienced sprinters in Experiment 2 were equally familiar with the focus cues provided across attentional focus conditions.

Synthesizing the results of both experiments, the results of Experiment 1 are aligned with previous research showing that those with a moderate level of task experience benefit from an external focus opposed to an internal focus of attention (Ille et al., 2013; Wulf & Su, 2007). Moreover, participants in Experiment 1 also benefited from adopting their 'normal focus' (i.e., control) compared to an internal focus of attention (Porter & Sims, 2013; Stoate & Wulf, 2011). Conversely, the highly experienced sprinters in Experiment 2 showed similar performance across all focus conditions (i.e., internal, external and control), which has not been previously observed within the attentional focus literature. The authors of the present study hypothesize that the differential results observed across Experiment 1 and Experiment 2 were due to differences in the participants' experience levels (i.e., moderate versus high). Specifically, the highly experienced sprinters would have had a greater capacity to abstract similar subjective meaning from all three attentional focus cues (Corbin et al., 2015), as their action concepts and perceptual effect representations are more robust due to their experience level (Schack, 2004). Conversely, the collegiate soccer players would have had less capacity to abstract subjective meaning from the attentional focus cues, as they are less experienced at sprinting with an intent to optimize technical execution in an effort to maximize performance. Therefore, the collegiate soccer players would depend more on the substance of the cues provided. Thus, the internal focus degraded performance, while the external focus and the 'normal focus' adopted during the control condition resulted in performance optimization.

4.2. Kinetic data

The results from Experiment 2 make it difficult to interpret the hypothesis noted above, as there were no differences observed across any of the attentional focus conditions for 10-meter sprint times or any of the kinetic variables (i.e., TFavg, VFavg and HFavg). Interestingly, the results from Experiment 1 showed that while both the external focus and the control conditions resulted in significantly faster 10-meter sprint times compared the internal focus condition, there were no differences across attentional focus conditions for any of the three kinetic variables. Thus, these results did not support the hypothesis for Experiment 1, as the differences in sprint times across the attentional focus conditions could not be explained by the select kinetic variables recorded during the start. This result is surprising considering the evidence showing the importance of mass-specific horizontal propulsive force during the start of a sprint (Clark & Weyand, 2015; Morin et al., 2012; Rabita et al., 2015). However, similar results have been observed in broad jump performance (Ducharme et al., 2016; Wu et al., 2012), where an external focus resulted in superior jumping distance compared to an internal focus, despite there being no conditional differences in peak force. Conversely, Wulf and Dufek (2009) found that an external focus resulted in a larger lower body impulse and vertical jump height compared to an internal focus of attention. Similarly, Chow, Koh, Davids, Button, and Rein (2014) showed that improvements in horizontal jumping distance were associated with concomitant increases in horizontal impulse for participants (4th grade students) who were instructed to adopt an external focus of attention; however, no such changes were observed in those that were instructed to adopt an internal focus of attention. More recently, Bezodis et al. (2016) found that team sport athletes achieved faster 10-meter sprint times under a control condition compared to internal and external focus conditions that were not different from one another. The kinetics collected during a single step at approximately 5-meters showed that both the internal and external focus conditions resulted in greater peak vertical force than the control condition; however, no other kinetic variable, including average horizontal force, was shown to be significantly different across conditions. Thus, it is still unclear how the kinetic mechanisms underpinning 10-meter sprint performance are mediated by various attentional foci.

One possible explanation for the inconsistent relationship between attention mediated differences in performance and kinetics in the present study is the fact that force data was only measured during the initial starting step. Prior literature (Clark & Weyand, 2015; Rabita et al., 2015) has established that the initial push is a primary factor in acceleration performance, and provided the impetus for making the first step the focus of our kinetic investigation. However, it is possible that the participants' mechanics during the subsequent steps in the 10-meter sprint may have a large effect on the overall sprint time, as has recently been reported (Bezodis et al., 2016). Thus, the fact that force data was not collected past the first step may have obscured any potential relationship between attentional focus conditions and the kinetic data.

4.3. Limitations

The primary limitation of this study was that no manipulation checks were used. Specifically, the results presented above cannot be qualified against the participants' subjective reports of how successful they were in literally applying the attentional focus cues provided. Moreover, a manipulation check would have also afforded an opportunity to assess the 'normal focus' of the participants during the control condition.

A secondary limitation of this study is the qualification of experience level. Specifically, the collegiate soccer players in Experiment 1 were labeled as moderately experienced at sprinting, while the sprinters in Experiment 2 were labeled as highly experienced. While these labels were justified based on experience levels with the sprint task being assessed, there is still a possibility that the groups were more similar than different due to their shared familiarity with the task.

A third limitation is the potential influence of the coach instructing the participants and the participants themselves. Specifically, as the coach reading the instructions was familiar with the research in support of an external focus of attention, it is possible that subtle differences in tone and projection could have influenced the way the participants received the cues. Additionally, as is the case in any experiment where the participants know they are being assessed, there is a risk of the Hawthorne-effect.

A fourth limitation relates to the research showing that men and women differentially respond to visual cues meant to elicit an external focus and verbal cues meant to elicit an internal focus (Benjaminse, Otten, Gokeler, Diercks, & Lemmink, 2015). Thus, as Experiment 2 included men and women, this could have affected the results due to differences in the way that information is processed across genders. Furthermore, any investigation that compares participants of different experience levels may potentially encounter a ceiling effect in the more experienced group that does not exist in the less experienced group. However, given that one of the primary objectives of this dual-study was to investigate how experience level influences the effect of attentional focus on a gross motor task, we deemed this limitation to be a necessary function of the experimental design.

Finally, the fact that participant numbers were modest in both groups, and the fact that the populations were highly specific (i.e., collegiate soccer players and sprinters), the results should be applied cautiously until further research is done across a larger sample of heterogeneous groups.

4.4. Practical implications

The results of this study provide further support for the benefits of an external focus compared to an internal focus (Experiment 1) in practical situations where instruction is required. Furthermore, this study provides additional support for the role of experience level in mediating the influence of attentional focus on a continuous skill like sprinting (Experiment 1 and 2). Specifically, while an external focus may not provide an advantage for those with a moderate (Experiment 1) to high (Experiment 2) level of experience with sprinting relative to a control condition encouraging a 'normal focus', an external focus is still preferred over an internal focus of attention, as it encourages the learner to focus on goal-relevant dimensions of the task (i.e., movement effects). This is important, as practitioners will always use instruction within the context of practice, and therefore, the instructions should be used to direct attention to the movement effects (i.e., external) as opposed to the movement process (i.e., internal). However, as experience level increases, and the learner gains an understanding of action concepts and develops implicit motor plans, the relative benefit of an external focus over an internal focus may become reduced, resulting in no differential benefit of one category of focus cue over another within the context of an acute training session.

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