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Specific internal and external attentional focus instructions have differential effects on rowing performance

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ABSTRACT

Directing an individual to focus their attention on internal or external cues can influence performance of skill-based and endurance sports. The present study examined the effects of switching attention across different types of internal and external attentional foci in a rowing task. Novice rowers (19 male, 47 female) focussed attention on one of four different internal cues (or one of four different external cues) at discrete time points while completing a row on an ergometer. Overall, a focus on internal cues resulted in longer distance, higher power output, and higher heart rate than a focus on external cues. However, for the internal condition a focus on arm and leg muscles was associated with higher performance than a focus on breathing. For the external condition, a focus on exerting force on the handle produced higher performance than a focus on the movements of the handle or seat or on the sounds of the ergometer. Global instructions to focus internally or externally influenced performance, but the specific effects within these broad categories were also variable. The advice given to athletes and recreational exercises should consider both the broad attentional focus direction and the specific cues of the task to which attention is directed.

Where an athlete directs his/her attentional focus during sport has important implications for performance (Brick, Campbell, Metcalfe, Mair, & Macintyre, 2016; Tenenbaum & Connolly, 2007; Wulf, 2013). Research on the effects of attentional focus in motor skill learning has distinguished between two directions of attentional focus: internal and external (Wulf, 2013). An external focus occurs when an athlete allocates attentional resources towards the outcomes of the movement or the effects that the movement has on the environment. In contrast, an internal focus occurs when an athlete directs attentional resources inward towards the movement of the body or bodily sensations. Although this distinction uses broad concepts to define external and internal focus, it is necessary to use instructions that refer to specific cues when applying it to a given sport context. For example, attentional focus in a cycling task has been modified using instructions to focus on either smooth and circular pedalling, force development of the leg, angle of head position, or stimuli present in a cycling video (Schücker et al., 2016).

Previous studies examining the differential effects of internal and external attentional focus in sport have predominately focused on discrete or closed-skill tasks. For instance, researchers have used different instructions to modify participant's attentional focus during golf putting (Bell & Hardy, 2009; Pelleck & Passmore, 2017), dart throwing (Marchant, Clough, & Crawshaw, 2007), soccer dribbling (Beilock, Carr, MacMahon, & Starkes, 2002), basketball free throws (Zachery et al., 2005) and jumping (Porter, Anton, & Wu, 2012). The findings typically demonstrate enhanced performance (e.g., greater throwing accuracy) when an external focus of attention is adopted than when an internal focus is used or when no focus instructions are given. Wulf and colleagues have argued that an external focus is most beneficial for performance when it is focussed on the intended movement effect and promotes automaticity of movements (Wulf, 2013), with these concepts being incorporated within the broader OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016).

In contrast to discrete sporting tasks that require only a short period of movement, continuous or endurance movement tasks like swimming, running, rowing, and cycling require an individual to sustain attention and effort over a longer period of time. As such, identifying the impact of different attentional focus strategies on performance in these tasks is important as an individual may shift his/her focus of attention between internal or external foci over time (Brick et al., 2016). It is also important to determine whether the beneficial effects of an external attentional focus on performance that have been observed in motor skill learning research can also transfer to these tasks (see Wulf & Lewthwaite, 2016). Moreover, other factors such as pain perceptions

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and distractions, may also impact performance. Consequently, the findings from research examining the impact of external and internal foci on continuous performance tasks have been more variable (Brick, MacIntyre, & Campbell, 2014). Most researchers have measured performance by assessing movement economy. For instance, studies have shown that adopting an external focus of attention during a running task has resulted in reduced oxygen consumption and lower respiration frequency (i.e., better running economy) than an internal focus (e.g., Neumann & Piercy, 2013; Schücker, Hagemann, Strauss, & Völker, 2009; 2013). Similarly, better performance economy in the form of lower electromyography activity of the muscles has been found for an external focus relative to an internal focus during repetitive weight lifting exercises (Neumann & Brown, 2013; see Neumann, 2019 for a review). It is noteworthy that these tasks controlled physical effort across conditions by regulating the speed of the treadmill or the timing of lifting movements, respectively.

Fewer studies have examined the effect of internal and external attentional foci during continuous tasks that have not standardised physical effort. In such cases, the outcome measures have been based on speed or time, and less consistent results regarding the differences between external versus internal focus instructions on performance have been observed. For example, Freudenheim, Wulf, Madureira, Pasetto, and Corrêa (2010) explored the effects of attentional focus on swimming speed. Participants who were instructed to focus on pushing the water away from the body (external focus) swam significantly faster than those who were instructed to focus on the movements of the hands and legs (internal focus). In rowing, Connolly and Janelle (2003, Experiment 2) found improved rowing speed on a 2000 m ergometer trial when participants focused on either internal cues or external cues relative to a no instruction baseline. The external focus cues included the placing or other rowers in the environment, and internal focus cues included breathing, how their body felt, and technique. However, there was no difference in performance between these internal and external conditions. Taken together, the contradictory findings likely reflect the different internal and external focus instructions, the varied and uncontrolled nature of the tasks, or a combination of both.

Evidence suggests that it is not only the internal versus external distinction that influences performance, but also the nature of the specific cues within each attentional focus. For instance, performance using an external focus of attention may be better when external cues are distal rather than proximal (Porter et al., 2012). McNevin, Shea, and Wulf (2003) observed superior balance performance when participants were instructed to focus on markers placed further away from the participants' feet compared to when participants were instructed to focus on markers closer to their feet. Similarly, McKay and Wulf (2012) found that novice dart throwers had greater throwing accuracy when instructed to focus on the end target (distal external focus) than when they were instructed to focus on the flight of the dart (proximal external focus). For internal focus instructions, Schücker, Knopf, Strauss, and Hagemann (2014) found greater detriments to running economy in a sample of regular runners when participants focused internally on automated processes (i.e., breathing and movement execution) than when they focused on the overall feelings of the body. These latter findings suggest that not all internal foci negatively impact performance to the same degree.

Recently, Brick et al. (2014) proposed a working model of attentional focus in endurance sport to explain how different internal foci affect performance. Specifically, Brick et al. distinguish between *internal sensory monitoring* which involves focusing on physiological responses such as breath, perspiration, or muscle soreness. In contrast, *active self-regulation* involves a focus on performance-related factors such as technique, pacing, or cadence. The authors suggest that focusing internally on physiological reactions may exacerbate feelings of exertion and subsequently decrease movement economy, whereas focusing internally on pace or cadence may enhance movement economy and performance. Although this is at odds with the findings reported by Schücker et al. (2014; 2016), there is some evidence that focusing internally on task-relevant cues may indeed benefit performance, particularly for novices.

For novice athletes, focusing internally on task-relevant cues may be more beneficial as this can allow for more step-by-step control of the movement compared to when focusing on task-irrelevant cues (Beilock et al., 2002; Castaneda & Gray, 2007; Vast, Young, & Thomas, 2011). For example, Pelleck and Passmore (2017) found that for novice golfers, focusing internally on features that were more task-relevant (i.e., hands and elbows) was less detrimental to putting accuracy than when focusing on internal cues that were less task-relevant (i.e., body position). In contrast, no differences in putting accuracy were observed across any of the different focus conditions for skilled golfers. Cauvillian and Fairbrother (2018) similarly found improved performance on a jump-rope task for novices when attention was focused on task-relevant upper body cues that were either internal (i.e., movement of the wrist) or external (i.e., movement of the handle), compared to when focus was directed towards task-irrelevant lower body cues that were internal (i.e., foot movement) or external (i.e., the sound of the jumps). Consistent with Brick et al.'s (2014) model, these findings suggest that internal focus instructions may benefit performance in some situations, such as if the task is unfamiliar and the cues are related to task- or performance-related outcomes.

The aim of the present research was to examine performance outcomes under different internal and external attentional focus instructions during a rowing task. The duration of the rowing trial was kept constant, but participants were free to vary their effort throughout the row. In addition, we controlled stroke rate so that effort would be primarily determined by the force exerted on the handle of the rowing ergometer. As a result, the primary outcome measures were distance travelled, power output, and physical exertion (heart rate). Connolly and Janelle (2003) suggest that a rowing exercise is well suited for manipulating attentional foci because of the physical and psychological intensity required during rowing. Moreover, rowing requires multiple points of full-body coordination and is unlikely to be easily automated without extensive practice. Participants were thus screened to ensure that they were of a similar (novice) level of experience in rowing. Previous research suggests that internal focus instructions result in reduced movement economy (Schücker et al., 2014; Wulf, 2013), and higher perceptions of effort (Lohse & Sherwood, 2011) relative to external focus instructions. However, the effects on physical effort when exertion is not controlled are less clear, particularly when participants are unfamiliar with a task. Novices may benefit from internal focus instructions that direct attention towards the movements relevant to the execution of a task relative to external focus instructions that promote automaticity (Beilock et al., 2002). It was therefore hypothesised that participants would row a greater distance and produce increased power output and physical exertion (heart rate) when instructed to direct their attention towards internal than towards external cues.

Consistent with Brick et al.'s (2014) model of attentional focus in endurance activities, the internal focus instructions switched between three conditions that focused on active self-regulation, with two being specific (exerting force through the arms and exerting force through the legs) and one being more general (overall technique), and a fourth condition that focused on internal sensory monitoring (breathing). It was hypothesised that a focus on exerting force through the arms or legs and a focus on technique would increase performance relative to a focus on breathing. The external focus instructions also varied across a focus on the effects of the movement on the environment. Participants focussed on exerting force on the handle, the movements of the handle or seat, and a focus on environmental sounds. A more distal external focus is suggested to result in more automated and efficient movements (e.g., McKay & Wulf, 2012). For this reason, a focus on environmental sounds and the movements of the seat were considered more distal to the operations of the rowing ergometer that determines speed and power (i.e., the handle and chain pulling on the flywheel). As such, we expected that a focus on these cues might result in greater movement economy, but less physical effort exerted, relative to a focus on the more proximal cues of the handle. It was therefore hypothesised that a focus on proximal external cues (i.e., focusing on the movement and exerted force on the handle) would result in increased physical effort than a focus on distal external cues (i.e., sounds of the ergometer, movement of the seat).

1. Method

1.1. Participants

Participants were 69 students (19 male, 50 female) enrolled in a psychology program who received partial course credit for their participation. A health history screening questionnaire (Sports Medicine Australia, 2005) excluded one participant. Two participants indicated they had previously been members of a rowing club and were excluded. The final sample consisted of 19 males and 47 females with a mean age of 24.54 years (SD = 8.06) and a mean Body Mass Index of 23.18 (SD = 4.03). Power analysis was conducted using G*Power 3.1 to determine the adequacy of the sample size. Few studies have reported effect size for the difference between internal and external attentional focus instructions on continuous tasks where physical effort was controlled. Freudenheim et al. (2010) reported a large effect ($\eta^2 = 0.15$) for the effect of specific attentional focus instructions on swimming speed. Connolly and Janelle (2003) did not report statistics for the specific comparisons between internal and external conditions although they reported a large overall effect ($\eta^2 = 0.23$) for the attentional focus conditions, which included dissociative conditions. A recent meta-analysis of balancing task performance found that the benefit of an external focus over an internal focus was medium ($d = 0.44$). No studies have examined differences between specific attentional focus cues (e.g., breathing, technique) during rowing. As such, power analyses were conducted using a conservative small to medium sized effect ($d = 0.40$), Type I error (α) of 0.05, Power = .90, and yielded a required sample size of 65 for the difference between attentional focus conditions, thus our obtained sample size was considered sufficient. During the previous 7 days before testing, participants engaged in a mean of 151.18 min (SD = 144.33) of vigorous exercise. Participants provided consent to a protocol approved by the institutional ethics committee.

1.2. Apparatus

Participants used a Concept 2 Model D Indoor Rower ergometer fitted with a P3 monitor. The ergometer was set to a drag factor of 105, which gave a moderate level of resistance. Heart rate was measured via a Polar Electro T31 chest strap that sent a wireless signal to the P3 monitor. The P3 monitor recorded stroke rate, distance, power, and heart rate at 30 s intervals. The monitor display was hidden from participants.

Video recordings lasting 6 min 5 s were made of a 21-year-old male fitness instructor rowing on the ergometer at 28–30 strokes per minute. The video was accompanied by a pre-recorded soundtrack and shown on a 23-inch display 1.2 m from the participant at the catch position. The instructor used a neutral tone of voice, thereby minimising the impact of positive or negative emotional cues on performance. The instructor prompted participants to focus on specific internal or external cues. The first instruction occurred directly after a 5 s countdown and the instruction to focus on a different cue was given at 30 s intervals. Four different cues were used in a predetermined sequence and repeated three times during the 6 min row. Table 1 shows the instructions for the attentional focus cues.

A demographic questionnaire was developed to record participant age, gender, height, weight, amount of vigorous physical activity during the preceding week, and previous rowing experience. In addition, participants provided exertion ratings using Borg's (1982) Ratings of Perceived Exertion (RPE) scale. The scale ranges from 6 (*very, very light*) to 20 (*very, very hard*), and positively correlates (r = 0.8 to 0.9) with heart rate (Borg, 1982). Participants also completed the Measure of Attentional Focus scale (Wininger & Gieske, 2010). This scale consists of six items where participants indicated the percentage of time they focused on body sensations, task-relevant thoughts, self-talk, task-relevant external cues, task-irrelevant thoughts, and external distractions. The six items must add up to 100%.

1.3. Procedure

Participants completed the experiment individually in a climate-controlled room. Participants first completed the informed consent, demographics questionnaire, and the pre-exercise screening questionnaire (Sports Medicine Australia, 2005). Next, participants familiarised themselves with the rowing ergometer and received verbal instructions on rowing technique and performance from the experimenter. This initial coaching phase ensured that participants would be familiar with the rowing task and able to interpret the instructional video that was later used to manipulate attentional focus. The experimenter coached participants on aspects of rowing technique, rowing at a steady rate of 28–30 strokes per minute, and on focusing attention on internal and external cues. This was done by the experimenter initially modelling rowing technique on the ergometer and then prompting the participant to emulate. The experimenter verbally referred to aspects of body movements, the importance of keeping the back straight for safety, and features of the ergometer (e.g., handle, flywheel, seat). The cues referred to in the instructional video were also explained by the experimenter as part of this initial coaching session. However, the specific attentional focus instructions were only given in the instructional video.

Participants completed two 6 min rowing trials, such that each participant completed one trial under the four different internal focus instructions and one trial under the four different external focus instructions. To ensure standardisation of instructions and focus of attention, participants completed the trials while viewing the instructional videos. As previously noted, the instructional videos required participants to direct their attention to a specific internal (or external) focus cue within each 30 s epoch. Thus, focus cues were varied across the rowing trial, although the cues were either all internal or external in nature in accord with participants' allocated condition. Condition order (internal, external) was counterbalanced across participants. Participants were asked to "row at the same stroke rate as the instructor while focusing your attention as instructed". Participants received a 5 min break after completion of the first rowing trial, during which time they completed the Measure of Attentional Focus scale and RPE and drank water. Participants next completed the second trial. Participants wore the heart rate monitor during both trials. At the completion of the second trial, participants again completed the Measure of Attentional Focus and RPE.

1.4. Statistical analyses

To test the manipulation of attentional focus, t-tests were conducted for each Measure of Attention Focus item (bodily sensations, task-relevant thoughts, self-talk, task-relevant external cues, task-irrelevant thoughts, and external distractions) to compare between the internal and external focus conditions. A t-test was also conducted to confirm that the stroke rate was similar between the two focus instruction conditions. For the main experiment, the independent variables were attentional focus and epoch (i.e., the time interval during the rowing trial). Epoch was included as a factor because the specific attentional focus cues were varied at 30 s intervals during the two attentional focus condition. Three separate 2 (attentional focus: internal, external) × 12 (epoch: 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330, 360 s)

Table 1
Attentional focus instruction cues at each 30 s interval (epoch).

Epoch	Attentional Focus Instructions	
	Internal	External
1, 5, 9	"Focus on moving and exerting force through your arms" (A)	"Focus on moving and exerting force on the handle" (A)
2, 6, 10	"Focus on moving and exerting force through your legs" (B)	"Focus on the movement of the seat beneath you" (B)
3, 7, 11	"Pay attention to and listen to your breathing in and out" (C)	"Listen to the sounds coming from the machine" (C)
4, 8, 12	"Focus on your overall technique" (D)	"Maintain smooth movements of the handle" (D)

repeated measures ANOVAs were conducted for the dependent variables of distance, power output, and heart rate. All analyses used an error rate of $\alpha = 0.05$. To examine significant interactions, simple effects analyses were conducted using *t*-tests, applying a Bonferroni correction (noted by α') to control for Type I error inflation.

Normality and homogeneity of variance assumptions were met. However, a Huynh-Feldt correction was applied for all analyses due to violation of the sphericity assumption. Heart rate was not recorded for two participants due to technical difficulties. Also, due to technical difficulties, one of those participants' epoch for all dependent variables was not measured although the total averages for the dependent variables were still recorded. As a result, these participants were not included for the analyses of heart rate or epoch, as relevant.

2. Results

2.1. Distance

The 2 (attentional focus) × 12 (epoch) repeated measures ANOVA revealed a main effect of attentional focus for distance, $F(1, 64) = 11.61$, $p = .001$, $\eta_p^2 = 0.15$. Participants rowed a greater distance per epoch when the instructions required a focus on internal cues ($M = 74.87$ m, $SD = 12.59$) than on external cues ($M = 72.94$ m, $SD = 12.27$). However, as shown in Figure 1, the difference between the internal and external conditions varied across epoch. This impression was supported by a main effect for epoch, $F(11, 704) = 9.02$, $\varepsilon = 0.43$, $p < .001$, $\eta_p^2 = 0.12$, and an attentional focus × epoch interaction, $F(11, 704) = 4.85$, $\varepsilon = 0.45$, $p < .001$, $\eta_p^2 = 0.07$. To compare the two attentional focus conditions, post-hoc pairwise comparisons were analysed for all 12 epochs (i.e., every time split) using a Bonferroni correction ($\alpha' = 0.0042$). As indicated in Figure 1, attentional focus direction for seven pairwise comparisons (epochs 120 s, 150 s, 180 s, 240 s, 270 s, 300 s, and 360 s) were significantly different, all $ts(64) > 3.08$, $p < .004$, $d > 0.38$. Distance was greater with a focus on exerting force through the arms than force on the handle, exerting force through the legs than movement of the seat, and overall technique than making smooth movements of the handle. In no comparisons did a focus on breathing differ from a focus on the sounds of the machine.

Figure 1 shows a pattern in which some types of internal attentional focus resulted in a greater distance travelled than other internal attentional focus types. Likewise, there were differences between the various external attentional focus types. Further analyses were conducted to explore this pattern. In these analyses only the second and third trial (i.e., epochs 150 s onwards) were examined to eliminate the first 30 s of the row when participants travelled a shorter distance due to having started from a stationary position.

The four internal attentional focus types were examined with a 2

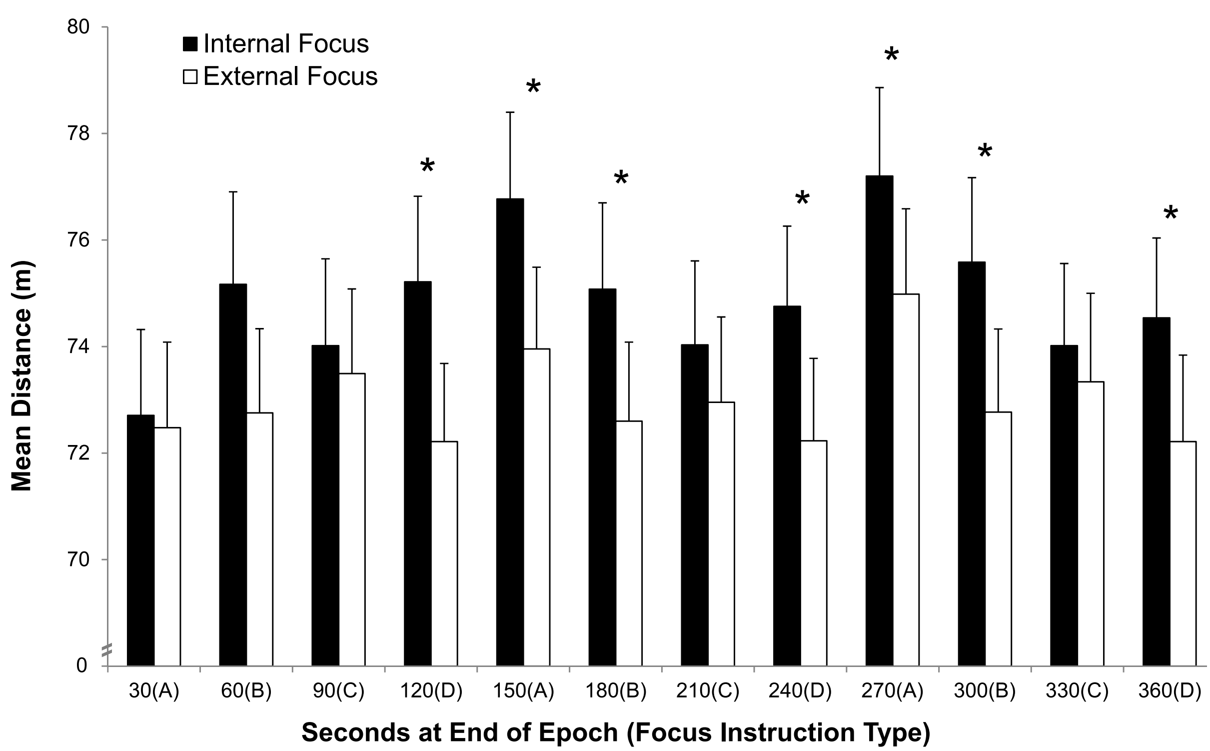

Figure 1. Mean distance rowed during each epoch of the trial under internal focus and external focus of attention instructions (for internal focus A = arms, B = legs, C = breathing, D = technique; for external focus A = force on handles, B = seat movement, C = sound of ergometer, D = smooth handle movement). Note: *$p < .004$.

(repetition: first, second) × 4 (internal type: arms, legs, breathing, technique) repeated measures ANOVA. The analyses showed a significant main effect for internal type, $F(3, 198) = 30.33$, $\varepsilon = 0.64$, $p < .001$, $\eta_p^2 = 0.32$, confirming differences across the focus types. The main effect and interaction involving the repetition factor were not significant, both $Fs < 1.99$, $p > .12$. Pairwise comparisons ($\alpha' = 0.0083$) showed that a greater distance was achieved with a focus on exerting force through the arms than a focus on the legs, breathing, and technique, all $ts > 5.56$, $p < .001$, $d > 0.67$. A focus on exerting force through the legs and a focus on technique yielded a greater distance than a focus on breathing, both $ts > 2.56$, $p < .006$, $d > 0.35$.

A similar 2 (repetition: first, second) × 4 (external type: handles, seat, sound, smooth) repeated measures ANOVA for the external focus types also yielded a main effect for external type, $F(3, 198) = 19.02$, $\varepsilon = 0.77$, $p < .001$, $\eta_p^2 = 0.22$. A focus on exerting force on the handle resulted in a longer distance than a focus on the seat movement, the sound of the ergometer, and making smooth movements of the handle, all $ts > 3.65$, $p < .001$, $d > 0.45$. A focus on the sound of the ergometer was also superior than a focus on making smooth movements with the handle, $t(66) = 3.48$, $p = .001$, $d = 0.43$. The main effect and interaction involving the repetition factor were not significant, both $Fs < 2.80$, $p > .057$.

2.2. Power output

The 2 (attentional focus) × 12 (epoch) repeated measures ANOVA yielded a main effect of attentional focus, $F(1, 64) = 10.87$, $p = .002$, $\eta_p^2 = 0.15$, and indicated that power output was greater when participants focused on internal cues ($M = 47.47$ W, $SD = 25.75$), than external cues ($M = 43.93$ W, $SD = 23.72$). A main effect for epoch, $F(11, 704) = 8.66$, $\varepsilon = 0.32$, $p < .001$, $\eta_p^2 = 0.12$, and an attentional focus × epoch interaction, $F(11, 704) = 4.35$, $\varepsilon = 0.44$, $p = .001$, $\eta_p^2 = 0.07$, suggested that power output differed between attentional focus conditions at each 30 s epoch. Post-hoc pairwise comparisons were conducted to compare focus types at each epoch ($\alpha' = 0.0042$). Figure 2 shows that attentional focus direction for five pairs (epoch 120 s, 150 s, 180 s, 240 s, and 300 s) were significantly different from each other, all $t(64) > 3.38$, $p < .004$, $d > 0.42$.

Further analyses were conducted to compare power across the specific internal focus instructions using a 2 (repetition: first, second) × 4 (internal type: arms, legs, breathing, technique) repeated measures ANOVA. The analyses yielded a significant main effect for internal type, $F(3, 198) = 23.92$, $\varepsilon = 0.54$, $p < .001$, $\eta_p^2 = 0.27$, and no significant effects involving the repetition factor, both $Fs < 2.07$, $p > .11$. Pairwise comparisons ($\alpha' = 0.0083$) showed that power was higher with a focus on arms than a focus on legs, technique, or breathing, all $ts > 3.55$, $p < .001$, $d > 0.56$, and for a focus on legs than a focus on breathing, $t(64) = 3.28$, $p < .002$, $d > 0.52$.

Similar analyses conducted for the external focus instructions using a using a 2 (repetition: first, second) × 4 (external type: handles, seat, sound, smooth) repeated measures ANOVA yielded a significant main effect for external type, $F(3, 198) = 14.80$, $\varepsilon = 0.93$, $p < .001$, $\eta_p^2 = 0.18$. Further comparisons ($\alpha' = 0.0083$) between the external focus conditions showed that power was greater with a focus on exerting force on the handles than the movements of the seat, making smooth movements of the handle, or the sounds of the machine, all $ts > 3.16$, $p < .002$, $d > 0.38$, and greater with a focus on sounds than making smooth movements, $t = 3.61$, $p < .001$, $d = 0.46$. All other comparisons were not significant using α-protected values, all $ts < 2.16$, $p > .03$. The main effect and interaction involving the repetition factor were not significant, both $Fs < 2.57$, $p > .07$.

2.3. Heart rate and perceived exertion

Heart rate was examined with a 2 (attentional focus) × 12 (epoch) repeated measures ANOVA. As shown in Figure 3, heart rate was greater when participants were focusing on internal cues ($M = 121.69$ bpm, $SD = 18.20$) than on external cues ($M = 119.48$ bpm, $SD = 18.20$). This impression was supported by a main effect for attentional focus, $F(1, 63) = 7.20$, $p = .01$, $\eta_p^2 = 0.10$. In addition, there

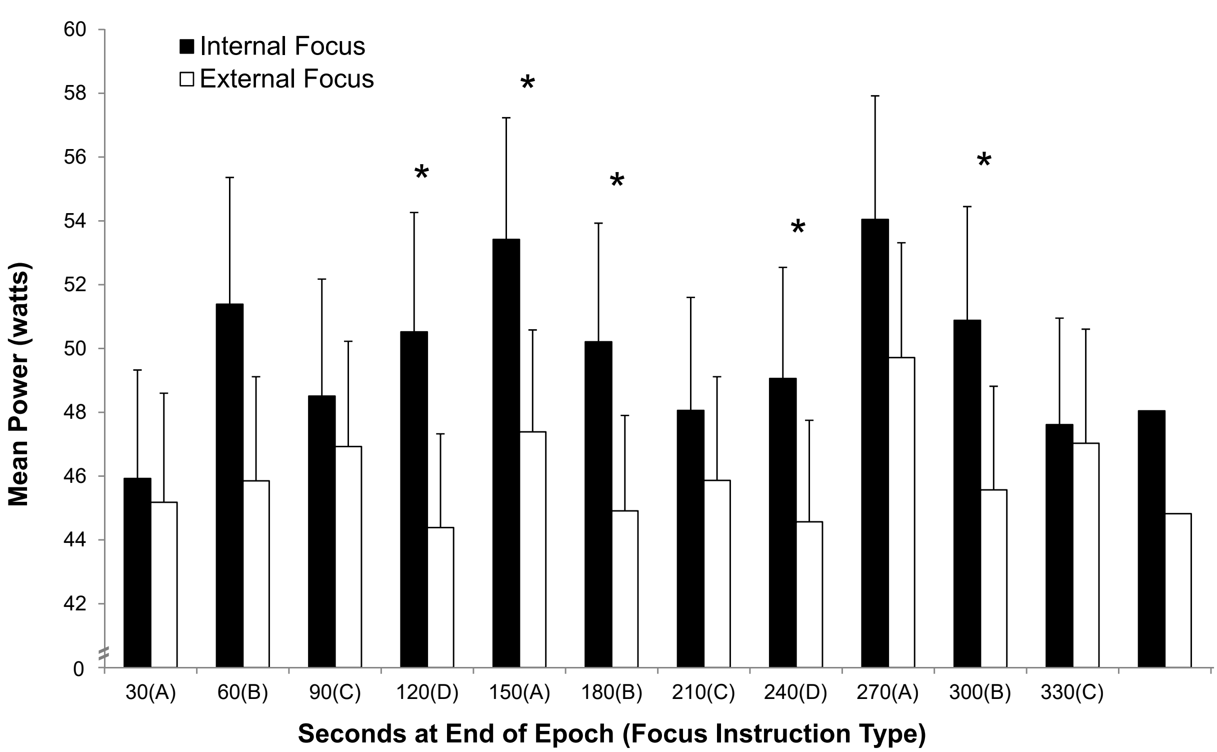

Figure 2. Mean power output during each epoch of the trial under internal focus and external focus of attention instructions (for internal focus A = arms, B = legs, C = breathing, D = technique; for external focus A = force on handle, B = seat movement, C = sound of ergometer, D = smooth handle movement). Note: $*p < .004$.

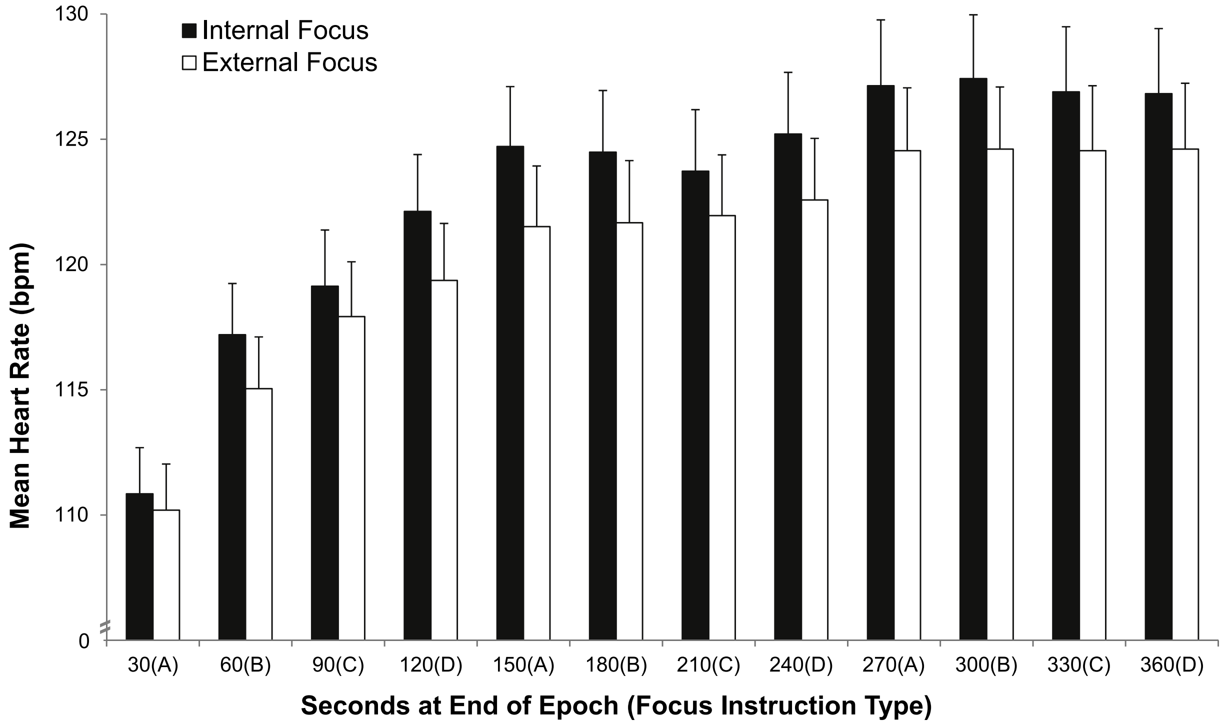

Figure 3. Mean heart rate during each epoch of the trial under internal focus and external focus of attention instructions (for internal focus A = arms, B = legs, C = breathing, D = technique; for external focus A = force on handles, B = seat movement, C = sound of ergometer, D = smooth handle movement).

was a main effect of epoch, $F(11, 693) = 81.40$, $\varepsilon = 0.19$ $p < .001$, $\eta_p^2 = 0.56$. However, unlike the performance measures, there was no significant attentional focus × epoch interaction, $F(11, 693) = 1.45$, $\varepsilon = 0.58$, $p = .20$, $\eta_p^2 = 0.02$. Further analyses to compare across successive epochs ($\alpha' = 0.0045$) indicated that heart rate increased from epoch 30 s–60 s, epoch 60 s–90 s, epoch 90 s–120 s, epoch 120 s–150 s, and epoch 240 s–270 s, all $ts > 4.51$, $p < .001$, $d > 0.56$. The pattern indicated that heart rate increased across time before stabilising near the end of the trial. Finally, ratings of perceived exertion showed no significant differences between the internal ($M = 11.56$, $SD = 1.87$) and external ($M = 11.45$, $SD = 1.50$) focus instructions, $t(65) = 0.55$, $p = .59$.

2.4. Manipulation checks

To confirm that stroke rate did not differ between conditions, a 2 (attentional focus) × 12 (epoch) repeated measures ANOVA was conducted. The main effect and interaction for attentional focus were not significant, both $Fs < 1.93$. $p > .05$. The mean stroke rate across all epochs was 28.01 strokes/min ($SD = 1.00$) for the internal focus condition and 27.96 strokes/min ($SD = 0.99$) for the external focus condition which was close to the target 28–30 strokes/min in the instruction video.

The Measure of Attentional focus was examined to determine what participants reported focusing attention on during the row. Using *t*-tests, a significant difference between reports of bodily sensations was found, $t(65) = 3.01$, $p = .004$, $d = 0.37$, with higher reports of bodily sensations when instructions required a focus on internal cues ($M = 22.08$, $SD = 18.30$) than external cues ($M = 17.29$, $SD = 16.19$). Results further revealed a significant difference for task-relevant external cues, $t(65) = 2.42$, $p = .018$, $d = 0.30$, with mean scores indicating higher reports of task-relevant external cues during the external focus condition ($M = 25.47$, $SD = 18.19$) than during the internal focus condition ($M = 21.15$, $SD = 16.72$). Reports for task-relevant thoughts, $t(65) = 1.01$, $p = .315$, self-talk, $t(65) = 1.36$, $p = .179$, task-irrelevant thoughts, $t(65) = 0.30$, $p = .762$, and external distractions, $t(65) = 1.83$, $p = .072$, were not significantly different between attentional focus conditions.

3. Discussion

The present study examined the effects of specific internal and external attentional focus instructions on performance outcomes in a rowing task. Overall, a focus on internal cues produced better performance (greater distance, more power output per stroke) and greater physical exertion (heart rate) than a focus on external cues. Interestingly, this difference in performance did not result in greater perceived exertion for the internal focus condition relative to the external focus condition. As expected, substantial variability was observed across the specific internal and external focus cues. For the internal focus condition, a focus on exerting force through the arms and legs and overall technique resulted in greater distance rowed and increased power output than a focus on breathing. For the external focus condition, a focus on exerting force through the handle produced higher performance than a focus on the seat, making smooth movements with the handle, or sounds of the ergometer. A focus on the sound of the ergometer also produced greater power than a focus on making smooth movements with the handle. Taken together, the results suggest that both the broad attentional focus category and the specific focus cues within each category are important to performance during the continuous performance of a rowing task.

The observation of better overall performance with internal focus instructions over external focus instructions contradicts that generally found within the motor skill learning literature (Wulf, 2013). Even when the internal and external focus instructions are applied to continuous or repetitive motor tasks like running, cycling, and weight lifting the evidence shows that performance is better with an external focus (Neumann, 2019; Schücker et al., 2009; 2013; 2014). However, there is a key difference between prior research and the present study in the way the tasks are implemented. Prior research has been primarily designed to examine differences in movement economy (e.g., oxygen consumption) under a constant physical load. Therefore, prior paradigms have used tasks that constrain the level of performance output needed, such as by controlling the speed of the treadmill or pace of cycling with a set gear ratio. In contrast, participants in the present study were required to limit their stroke rate. However, this did not constrain the effort exerted because participants could vary the power of each stroke. As such, the present findings and those of prior research are not necessarily incompatible. As movement economy was not measured in the current study, it cannot be ruled out that the present internal focus conditions produced movements that were less economical than an external focus (e.g., body movements were less coordinated or muscle activation spread to less focal muscles). However, the findings suggest that a focus on internal cues promotes an increase in effort and, by extension, performance as measured by metrics like power and distance.

Another explanation for the superior performance observed in the current study when focusing internally might be the novice sample examined. Beilock et al. (2002) suggest that novice athletes automatically adopt an internal focus of attention due to the unfamiliar nature of the task. When a task is unfamiliar, novices must hold large amounts of procedural information in working memory which increases cognitive load and makes it difficult to shift to an external focus of attention, even when instructed to (Gray, 2011; Vast et al., 2011). In contrast, experienced athletes automatically adopt an external focus of attention because they already have proceduralised knowledge of motor movements (Beilock et al., 2002; Vast et al., 2011). In the current study, participants were reminded prior to each row to maintain the same stroke rate as the rowing instructor and to keep a straight back. Consequently, because the rowing movements had not yet become automated and cognitive load demands were high, the current sample of novice rowers may have had greater difficulty maintaining performance whilst simultaneously focusing on external cues that were less relevant to the step-by-step performance of the task (Castaneda & Gray, 2007). In this way, participants may have reduced the physical effort they exerted during the external focus condition to maintain adherence to task instructions and this, by extension, may have reduced their performance.

The increased distance and power output with an internal focus relative to an external focus may have been produced by an increase in muscular effort rather than more coordinated or fluid movements. Supporting this interpretation are the heart rate findings, whereby heart rate was significantly higher in the internal focus condition than the external focus condition. However, it is recommended that future research use electromyographic recordings to directly measure muscle fibre activation when implementing different attentional focus instructions. For instance, prior research that has examined weight lifting tasks has shown that a focus on specific muscle groups (relative to a focus on the movements of the bar) increases activity of the muscles being attended to, and that this activation can spread to nearby muscles (see Neumann, 2019). A similar increase in muscular effort and muscle fibre activation might be expected when focusing on muscles during a rowing task.

A significant finding in the present study was the observed differences within the broad categories of internal focus and external focus conditions. For the internal focus conditions, distance and power were greater with a focus on the arms, legs, and technique than a focus on breathing. Moreover, a focus on the arms produced greater power than a focus on the legs and technique. The different attentional foci may be interpreted within the attentional focus model for endurance activity proposed by Brick et al. (2014). Thus, the present findings indicate that, when focusing internally, a focus on self-regulation states can produce higher performance than a focus on internal sensory monitoring. Consistent with this interpretation, Brick et al. (2014) stated that a focus on breathing was an example of internal sensory monitoring and that a focus on technique was an example of active self-regulation. Brick et al. (2014) did not specifically discuss a focus on moving and exerting force through the arms (or legs), which was two conditions used in the present study. However, such a focus appears to reflect predominantly active self-regulation based on their definition related to efforts to control or monitor thoughts, feelings, or actions. The fact that the increases in power and distance for the focus on arms and legs was similar to that found with a focus on technique supports this interpretation. However, as controlling actions may involve monitoring some feedback from the body, it is possible that a focus on the movement and force of the arms and legs could have an internal sensory monitoring component.

For the external focus conditions, it was expected that a focus on proximal external cues (i.e., movement and exerted force on the handle) would result in more physical effort than a focus on distal external cues (environmental sounds, movement of the seat). Results generally supported this prediction and revealed that distance and power were greater with a focus on exerting force on the handle than a focus on the sound of the machine, movements of the seat or making smooth movements of the handle. Moreover, power and distance were greater with a focus on the sounds of the machine than making smooth movements of the handle. These findings suggest that focusing on external cues that are closely related to performance outcomes can enhance the performance of novice rowers more than focusing on external cues less closely linked to performance. This interpretation is consistent with the results reported by Cauvillian and Fairbrother (2018) who observed better jump-rope performance in novices when attention was directed towards proximal external cues (i.e., movement of the jump-rope handle) versus distal external cues (i.e., sound of the jumps). Unexpectedly, however, in the current study an external focus on the sounds of the machine (distal) was found to result in better performance than a focus on making smooth movements of the handle (proximal). This finding may be due to the increased complexity and balance required to maintain smooth movements of the handle compared to simply focusing on the amount of force that is exerted. That is, participants may have decreased their speed and power output when focusing on maintaining smooth movements of the handle because this action was not automated and therefore required greater cognitive control (Vast et al., 2011).

The present results have practical implications for coaches and athletes in rowing, and potentially other continuous movement sports. The findings suggest that a focus on internal cues can promote greater physical effort and outcomes than a focus on external cues. Such instructions could thus be particularly useful during training to develop aerobic endurance or during competition when maximal effort is required. Likewise, fitness instructors might have their clients focus on internal cues more than external cues to maximise motivation and effort. In addition, the present findings indicate that the specific cues focussed on are important. For example, a focus on the arms yielded better performance than all other cues. As such, coaches and athletes should avoid nonspecific internal (e.g., “body”, “movement”) or external (e.g., “other people”) cues. The use of specific attentional focus cues may be particularly important for tasks requiring complex movements and coordination where there are multiple cues available to focus on at any one time.

A strength of the current study was that the internal and external focus instructions were similar in wording and structure. Previous research that has manipulated attentional focus has been criticised for using non-standardised instructions across conditions, thus introducing confounding factors that could have influenced the results (Wulf, 2013). Attempts were made in the present study to make the instructions as similar as possible across the broad internal and external focus conditions even when the cue attended to was substantially different. For example, participants were instructed to attend to breathing (internal focus) or the ergometer machine (external focus) by listening to the sounds associated with each. Arguably the most similar instructions in the present study were those that instructed participants to focus on exerting force through the arms (internal focus) versus exerting force through the handle (external focus). For these specific instructions, distance and power output were significantly greater in the internal focus than the external focus condition when the two conditions were compared separately for each epoch. Similar differences were found when comparisons were made at each epoch for the focus instructions for the legs (internal) versus the seat (external) and for technique (internal) versus smooth movements of the handle (external). These findings provide evidence that the results reported here are unlikely to have been confounded by differences in the wording of the instructions across conditions and can be strongly attributed to our manipulation of attentional focus.

Notwithstanding the strength in the methodology, there were some limitations. The present findings relate to one aspect of performance, namely short-term changes in distance and power output. However, performance can be quantified in other ways. Movement economy at an aerobic level (e.g., oxygen consumption) or muscular level (e.g., electromyographic activity) have been common measures when examining internal and external focus effects. The ability to sustain effort over an extended period of time (i.e., endurance) is another important aspect to performance which was not considered in the present study. Although a focus on exerting force through the arms and legs may be most beneficial for short-term increases in power, such instructions could be less effective for overall endurance performance over a long period of time. Further research should examine such issues. As the present results have shown, an external focus of attention may not necessarily result in greater movement economy, better endurance performance, and higher power output simultaneously. Another potential limitation is that despite counterbalancing the order of the internal versus external attentional focus instructions, the specific instructional cues within each attentional focus condition could also have been counterbalanced. The instructions were also only delivered by a male fitness instructor via a video recording. Future research should counterbalance the gender of the instructor to avoid any potential gender bias. Finally, although our measure of attentional focus supported the conclusion that participants attended broadly to internal or external cues as appropriate for the condition, this manipulation check did not examine the specific cues that participants attended to.

In conclusion, the present study supports the notion that both broad attentional strategies and more specific attentional focus cues are important for performance. Coaches and athletes should reflect upon both aspects when developing mental skills that aim to enhance training outcomes and competition performance. A focus on exerting force through parts of the body that are most proximal to performance outcomes has the potential to produce short-term increases in performance, although it remains to be determined whether this negatively impacts longer-term sustained effort and movement economy. Overall, the present findings encourages athletes to be flexible in their approach and focus attention towards relevant internal or external cues as required for a given performance situation.

CRediT authorship contribution statement

David L. Neumann: Conceptualization, Methodology, Formal analysis, Resources, Data curation, Writing - original draft, Writing - review & editing, Supervision. **Nicholas Walsh:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Robyn L. Moffitt:** Writing - review & editing. **Thomas E. Hannan:** Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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