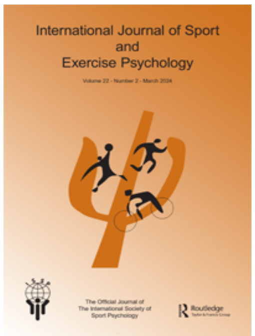

International Journal of Sport and Exercise Psychology

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rijs20

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To cite this article: Robyn Sullivan, Liis Uiga, Rich Masters, Greg Anson & Arne Nieuwenhuys (04 Apr 2024): Influence of an audience on conscious motor processing and performance during a go-only and stop-signal soccer penalty shooting task, International Journal of Sport and Exercise Psychology, DOI: 10.1080/1612197X.2024.2336164

To link to this article: https://doi.org/10.1080/1612197X.2024.2336164

Published online: 04 Apr 2024.

INTERNATIONAL JOURNAL OF SPORT AND EXERCISE PSYCHOLOGY
https://doi.org/10.1080/1612197X.2024.2336164

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Influence of an audience on conscious motor processing and performance during a go-only and stop-signal soccer penalty shooting task

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ABSTRACT

The Theory of Reinvestment predicts that perceived pressure to perform well can negatively impact the perceptual-motor skills of experts, by promoting conscious reinvestment of explicit knowledge about how the skills should be performed (i.e., "conscious motor processing"). This study sought to investigate the influence of pressure on conscious motor processing and performance in a soccer (football) penalty shooting task. Performance was compared in an "execution-only" and "dynamic" task context, in which fifteen experienced soccer players were required to accurately shoot on target (execution-only) or, if the goalkeeper moved to intercept, inhibit their shot (dynamic). Pressure was manipulated by means of a small audience. Manipulation checks of conscious motor processing were taken, and performance measures included movement time, reaction time, inhibition success, and penalty shooting accuracy. Analyses indicated that penalty shooting accuracy was lower in the dynamic than in the execution-only task context ($p = .01$). Presence of an audience did not increase perceived anxiety, nor did it result in significant effects on conscious motor processing or penalty shooting performance. Covariate analyses identified trait reinvestment as a significant covariate. Whilst in general, presence of an audience had no significant effects on conscious motor processing or penalty shooting performance, high (trait) reinvestors were found to engage more in conscious motor processing, initiated their responses earlier (allowing more time for execution), and showed improved response inhibition in the presence of an audience. Future studies are required to further evaluate the influence of trait reinvestment on conscious motor processing and performance under pressure.

ARTICLE HISTORY
Received 20 December 2023
Accepted 22 March 2024

KEYWORDS
Anxiety; reinvestment; perceptual-motor performance; stop signal task

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Introduction

Decisive moments, such as taking a penalty in soccer, a free-throw in basketball, or a crucial putt in golf, are often considered to be the pinnacle of high-pressure performance. One commonly adopted perspective suggests that in such moments, where "all eyes are on you", the increased importance of doing well can trigger athletes to consciously process movement-related information and "reinvest" explicit knowledge about how to correctly perform motor skills (Masters, 1992; Masters & Maxwell, 2008; Sullivan et al., 2022). In expert performers, across a wide range of motor skills, reinvestment has been shown to disrupt previously automated control of movement and decrease performance (for a review see Masters & Maxwell, 2008). Against this background, the current study set out to investigate whether effects of pressure on conscious motor processing and performance may extend to "dynamic" performance situations, where previously afforded actions may be rendered obsolete and skill execution may suddenly need to be cancelled in light of new information.

While it has been suggested that reinvestment can be caused by several contingencies, such as time available, movement disorders, or boredom, arguably the most investigated contingency is performance pressure (Masters & Maxwell, 2008; Sullivan et al., 2022). Performance pressure arises when incentives to perform well are high and is typically associated with increased self-awareness and feelings of anxiety. According to Nieuwenhuys and Oudejans (2012, 2017), increased anxiety promotes stimulus-driven attention and limits an individual's ability to deliberately focus on task-relevant information. This can lead to distraction, as attention is drawn towards threat-related information. However, when anxiety causes attention to be drawn to the to-be-performed movement itself, it can also cause performers to attempt to deliberately control their movements. According to the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008), conscious control of movement is particularly disruptive for expert performers, who are normally able to execute movements with minimal cognitive involvement. Conscious control, in this case, disrupts automaticity, increases opportunity for errors (as execution proceeds in a "step-by-step" fashion), and negatively impacts the overall level of performance.

A recent systematic review, which examined the conscious motor processing and pressure-performance relationship, confirmed that increases in performance pressure are often associated with increased engagement in conscious motor processing (Sullivan et al., 2022). For instance, Gray (2004; Experiment 3) determined that participants performing baseball batting under pressure showed increased attention for movement-related information (i.e., as examined with a skill-focused dual-task). Similarly, using electroencephalography (EEG), Lo et al. (2019) determined that when performing a dart throwing task under pressure individuals with a propensity to reinvest showed elevated F3-Fz coherence during task execution, which is thought to be a neural marker of verbal-analytical engagement in the control of movement (e.g., Zhu et al., 2011, but see Parr et al., 2023). Thus, there is evidence that performance pressure can result in increased conscious motor processing during sporting tasks. However, while many of the studies included in Sullivan et al.'s (2022) review interpreted pressure-induced increases in conscious motor processing to be responsible for observed changes in performance, few studies directly investigated this. Evidence in this regard was deemed to be "inconclusive" and it was concluded that more studies were required to determine if pressure-induced changes in conscious motor processing directly contribute to observed changes in performance (Sullivan et al., 2022).

Previous research suggests that not all individuals are equally inclined to engage in reinvestment or to be anxious under pressure. Indeed, factors such as fear of negative evaluation, self-consciousness, experience, and dispositional reinvestment have all been shown to influence the extent to which individuals experience anxiety and how they respond to pressure (e.g., for reviews see Masters & Maxwell, 2008; Mosley & Laborde, 2016). For instance, with regards to reinvestment, Maxwell et al. (2006) determined that expert golfers who were high reinvestors showed increased use of explicit task-relevant knowledge and lower levels of performance compared to low reinvestors, specifically in self-awareness evoking conditions (presence of a video camera and television). Thus, whilst conscious motor processing can be elicited by pressure-filled performance situations, propensity for reinvestment can play an important role in determining the actual level of engagement and impact.

Existing work on conscious motor processing and performance under pressure has traditionally focused on isolated skill execution; for example, a golf putt, a basketball free throw, or dart throwing (e.g., Cooke et al., 2011; Gray, 2004; Gray et al., 2013; Lo et al., 2019). In such "execution only" paradigms, there is often a lot of time available prior to performing the movement, which may increase the opportunity to engage in conscious motor processing (Masters & Maxwell, 2008). Moreover, by focusing on skill execution alone, opportunity to engage in conscious motor processing is increased as performers do not have to consider potential alternative courses of action. Whilst this is characteristic of some sport situations, others are characterised by multiple opportunities for action (Oudejans & Nieuwenhuys, 2009). For instance, a soccer player approaching the goal may choose to continue to dribble, pass, or shoot the ball, often with little time to consider and choose between options (Corrêa et al., 2016). Similarly, an initiated course of action may sometimes need to be cancelled or altered (e.g., when an opponent's response renders a previously existing opportunity obsolete). Arguably, with attention being divided between skill execution and possible alternative courses of action (including action cancellation), such "dynamic task contexts" may increase attentional demands and limit the extent to which conscious motor processing can occur and be responsible for skill breakdown under pressure.

To investigate the effect of task context ("execution only" vs. "dynamic") on conscious motor processing and performance under pressure, the current study examined the influence of an audience on performance in an adapted "stop-and-go" soccer penalty shooting task, requiring participants to accurately shoot on target (go-trial) or, if the goalkeeper moved to intercept, inhibit their shot (stop-trial). In the execution only task context, only go-trials were performed. In the "dynamic" task context, go-trials were intermixed with stop-trials. Regarding the main effect of pressure (Hypothesis 1), it was hypothesised that presence of an audience would increase engagement in conscious motor processing and decrease penalty shooting performance (Masters, 1992; Masters & Maxwell, 2008). In addition, and in line with previous work investigating penalty shooting in dynamic task contexts (e.g., Navarro et al., 2012), it was expected that presence of an audience would decrease stopping success (dynamic task context only), as more time may be required under pressure to process task-relevant information. Regarding the main effect of task context (Hypothesis 2), it was hypothesised that the attentional load associated with the possibility of stopping, would cause engagement in conscious motor processing to be less. Furthermore, with attention being drawn to the possibility of stopping, penalty shooting performance was expected to be worse in the dynamic as compared to the execution only task context. Regarding the interaction between pressure and task context (Hypothesis 3), it was hypothesised that observed effects of pressure on performance would be mediated by observed changes in conscious motor processing in the execution only task context, but that this mediating effect would be less in the dynamic task context. Finally, regarding the influence of trait reinvestment (Hypothesis 4), we hypothesised that high reinvestors would show increased conscious motor processing and decreased penalty shooting performance compared to low reinvestors, especially in the presence of an audience (Masters & Maxwell, 2008). Conversely, due to their tendency to control movement in a step-by-step fashion, it was expected that high reinvestors would be more successful than low reinvestors at inhibiting their responses in the dynamic task context (e.g., Park et al., 2020).

Methods

Ethical approval for the study was obtained from the XXXXXXXXXX Human Participants Ethics Committee (Reference XXXXXXXXXX).

Participants

Based on a power analysis using effect sizes obtained from previous studies investigating the effect of pressure on conscious motor processing and performance in sport tasks (e.g., Cooke et al., 2011; Lo et al., 2019; GPower; within-subject ANOVA, $f = 0.40$, 95% power, $\alpha = 0.05$), a sample of 15 healthy experienced soccer players (3 females, 12 males) aged 20–45 ($M = 29.40$, $SD = 8.30$) was recruited. Participants' soccer experience ranged from 2–30 years ($M = 15.47$, $SD = 7.10$). Ten participants indicated they played soccer competitively, while five indicated they played socially. Thirteen players were right leg dominant and two were left leg dominant.

Participants' general tendency to engage in conscious motor processing and decision reinvestment during skill execution was assessed using the Movement Specific Reinvestment Scale (MSRS; Masters et al., 2005; $M = 37.00$, $SD = 10.93$) and Decision-Specific Reinvestment Scale (DSRS; Kinrade et al., 2010; $M = 31.07$, $SD = 6.84$). Participants' disposition for competitive anxiety was assessed using the Sport Competition Anxiety Test (SCAT; Martens, 1977; $M = 16.33$, $SD = 4.19$). Participants were aware of the general purpose of the study (e.g., effects of pressure on penalty shooting performance), but were unaware of the study hypotheses. Written informed consent was obtained from each participant prior to completing the study.

Experimental design

The current study investigated the effects of an audience and task context on conscious motor processing and penalty shooting performance, using a 2 × 2 (audience x task context) within-subject design, in which each participant completed a series of soccer penalty kicks in both task contexts (i.e., execution-only vs. dynamic) under both audience and no-audience conditions. To manage time demands, audience and no-audience conditions for each participant were conducted on separate days, with on average 26 days (SD = 25.5) between sessions. The order of conditions (i.e., audience vs. no audience) and task contexts (i.e., execution only vs. dynamic) was counterbalanced across participants.

Experimental task and conditions

The experiment took place in a large (indoor) laboratory setting. Consistent with Wood and Wilson (2010), participants took penalties in an adapted situation from a distance of 5 metres, as in five-aside indoor soccer, facing a downsized goal and goalkeeper that were projected onto a 5 m by 3 m white tarpaulin. Depending on their foot dominance, participants were positioned 2 m behind and ∼1 m to the left or right of the ball (Hart Sport Pro, Size 5), to allow for a short two-step "run-up". During each trial, a target (width: 90 cm, height: 70 cm) was presented in either the left or right bottom corner of the goal to mark trial start (i.e., go-signal; see Figure 1). To ensure that participants initiated their run-up in a timely fashion and to prevent strategic slowing in anticipation of goalkeeper movement (a known strategy in stop-signal tasks; see Wadsley et al., 2023), a maximum response time of 1s was implemented and trials in which participants responded "late" were repeated. Participants were instructed to aim for the centre of the target, unless the goalkeeper moved in the direction of the target (i.e., stop-signal; see Figure 1), in which case they were instructed to fully inhibit their kick.

In the execution-only task context, 100% of trials were go-trials. Thus, the goalkeeper remained in the centre of the goal and no stop signals were presented. Participants performed 4 blocks of 24 test trials (i.e., 96 trials in total). In the dynamic task context, 2/3 of trials were go-trials and 1/3 of trials were stop-trials. On stop-trials, the stop signal (i.e., movement of the goalkeeper) was presented at one of four fixed time points following presentation of the go-signal (i.e., 1200, 1300, 1400, and 1500 ms). To maximise sensitivity, stop times were selected based on extensive pilot testing such that stopping success was relatively easy at the earliest timepoint, moderately difficult at the middle two timepoints, and very hard at the latest timepoint. As in the execution-only task context, participants

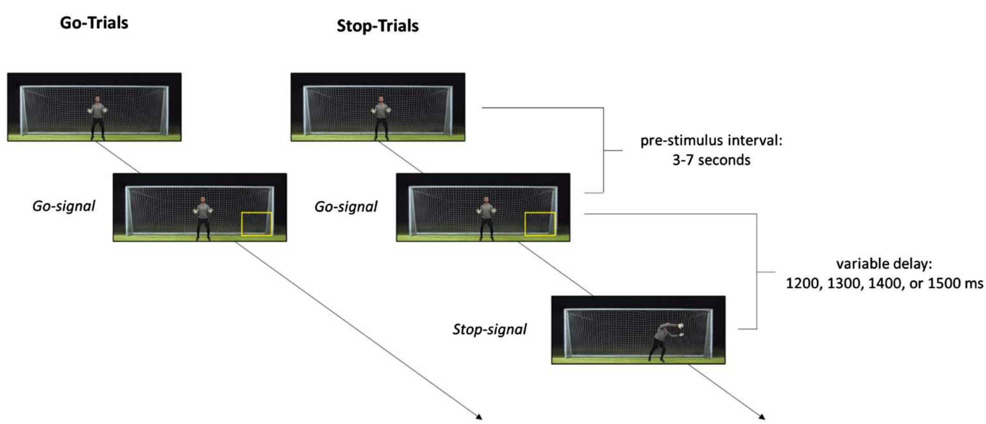

Figure 1. Visual stimuli during Go-trials and Stop-trials.

completed 4 blocks of 24 test trials in the dynamic task context (i.e., 96 trials in total); however, in each block 8/24 trials were stop-trials and each stop time was presented twice. Stop- and go-trials were randomly distributed within blocks. Prior to performing in each task context, participants received 10 familiarisation trials. A brief 1-minute break was taken between each block of 24 trials. Between task contexts, a longer 5-minute break was provided to allow for sufficient recovery.

Performance pressure was manipulated by introducing a small audience to observe participants during their performance (i.e., audience vs. no-audience). Previous studies have successfully used audience observation to induce self-awareness and anxiety in athletes (Masters, 1992; Mesagno et al., 2012; Navarro et al., 2012). In line with procedures utilised by Mesagno and colleagues (2012), the current study used a small audience of four students unknown to the participants, with students positioned two metres away on either side of the participant (i.e., two per side) who were instructed to remain silent for the duration of the study.

Dependent variables

Manipulation check

Participants' state anxiety was assessed using the five cognitive anxiety items (e.g., "I am concerned about losing" or "I am concerned about choking under pressure") from the Revised Competitive State Anxiety-2 (CSAI-2R; Cox et al., 2003) using a 4-point Likert Scale ranging from 1 (not at all) to 4 (very much so). Participants responded upon completion of each task context (i.e., execution-only and dynamic) in both conditions (i.e., low-pressure and high-pressure). Higher scores indicate greater state anxiety.

Participant's recovery and perceived levels of physical fatigue were monitored using an adapted 7-item version of the Hecimovich–Peiffer–Harbough Exercise Exhaustion Scale (HPHEES; Hecimovich et al., 2014). Example items include "how easily can you replicate your last set?" or "how much do your muscles ache?". Responses were measured on a 10-point Likert Scale ranging from 1 (not at all) to 10 (very much so), upon completion of each task context (i.e., execution-only and dynamic) in both conditions (i.e., audience and no-audience). Higher scores indicate greater physical fatigue.

Conscious motor processing

In line with the procedure utilised by Gray (2004), conscious motor processing was measured objectively during all go-trials using a skill-focus dual-task. This task involved a tone being presented at the time when, on stop trials, the stop signal would have been presented. Immediately upon completion of the kick, participants indicated whether the tone was presented *before* or *after* they contacted the ball. Accuracy of responses was verified based on actual kick completion times (see "Penalty Shooting Performance"), with higher accuracy suggesting increased conscious motor processing (Gray, 2004).

Additionally, an adapted 7-item state version of the MSRS (Huffman et al., 2009; Zaback et al., 2015) was used to assess conscious motor processing (i.e., "movement self-consciousness" and "conscious motor processing") subjectively. Examples of items include "I reflected a lot about my movements while performing the task" or "I was concerned about my style of moving while performing the task". Responses were measured on a

6-point Likert Scale, ranging from 1(strongly disagree) to 6 (strongly agree), upon completion of each task in both conditions. Higher scores indicate greater movement specific reinvestment during the task.

Penalty shooting performance

Penalty shooting accuracy was assessed from recorded video footage via cameras (Panasonic, HC-X900) positioned behind and above the participant. The number of successful shots within the target (% target hits) was calculated and compared between both audience conditions and task contexts. Reaction time was defined as the time (in seconds and milliseconds) between presentation of the target (go-signal) and participants' initiation of their run-up, as recorded via an air switch (RS Pro) that participants were positioned on at their starting location. Movement time was defined as the time (in seconds and milliseconds) between presentation of the target (go-signal) and participants' completing their kick (i.e., making foot-ball contact), as recorded via an optical gate (RS Pro), which was positioned directly behind the ball to detect initial ball displacement. The air switch and optical gate were interfaced with the task computer via a customised Arduino response board. Mean reaction times and movement times were compared between both pressure conditions and task contexts.

Stopping success

On stop-trials (dynamic task context only), for each fixed stop time (1200, 1300, 1400, 1500 ms), stopping success was defined as the percentage of stop-trials in which participants effectively inhibited their kick and was determined considering input from the optical gate (i.e., no response / no ball displacement). Stopping success (%) was compared between both pressure conditions.

Procedure

Participants were tested individually during two separate experimental sessions (i.e., audience/no audience). Prior to their arrival, participants completed the (trait) MSRS, DSRS, and SCAT. Upon arrival, the experimental task was described, and participants were provided the opportunity to ask questions prior to giving written informed consent. Participants then completed 192 penalty kicks across the execution-only and dynamic task contexts. Following each task context, participants completed the CSAI-2R, state MSRS, and HPHEES questionnaires. Upon completion of all trials, participants were provided a time to return for the second day of testing for the opposite audience condition. Experimental sessions lasted approximately 1.5 h each. At the end of the second session, participants were provided a NZ$30 voucher as a thank you for their participation.

Data analysis

Statistical analyses were conducted in SPSS 28.0. Distribution plots were visually checked for normality prior to conducting statistical analyses (Prabhaker et al., 2019). Effects of audience and task context on our manipulation checks (i.e., state anxiety; CSAI-2R scores), recovery (HPHEES; Item 1) and incremental physical fatigue (HPHEES; Items 2-

7), were examined using a 2 (audience) × 2 (task context) repeated measures ANOVA. Similarly, a 2 (audience) × 2 (task context) repeated measures ANOVA was also used to examine the effects of audience (Hypothesis 1) and task context (Hypothesis 2) on conscious motor processing (i.e., skill-focused dual task and state MSRS scores) and performance (i.e., penalty shooting accuracy, reaction times, and movement times). Effects of audience on stopping success (dynamic task context only) were assessed using a 2 (audience) × 4 (stop time) repeated measures ANOVA. To determine if conscious motor processing mediated the impact of pressure on performance (Hypothesis 3), a mediation analysis (MacKinnon et al., 2007) was planned. Finally, to examine the influence of trait reinvestment (Hypothesis 4), trait MSRS scores were entered as a co-variate in each of the above-mentioned analyses. In cases where the trait variable was a significant covariate, participants were split into low and high reinvestors based on a median split (as in Malhotra et al., 2012) and trait reinvestment was entered as an additional (between-subject) factor. [1]

For all ANOVAs, significant main effects and interactions were addressed using Bonferroni-corrected pairwise comparisons. If Mauchly's test of sphericity indicated that sphericity had been violated the Greenhouse-Geisser correction was applied. Effect sizes were calculated using partial eta squared (η_p^2) or Cohen's *d* depending on the statistical test. Finally, the alpha level for significance was set at $p = .05$.

Results

Manipulation check

Means and standard deviations for the manipulation checks (i.e., state anxiety and recovery) are presented in Table 1.

The ANOVA conducted on the CSAI-2R scores indicated no significant main effect of audience, $F(1,14) = 0.15$, $p = .71$, $\eta p^2 = .01$, no significant main effect of task context, $F(1,14) = 0.11$, $p = .75$, $\eta p^2 = .01$, and no significant audience × task context interaction, $F(1,14) = 0.01$, $p = .92$, $\eta p^2 = .001$. Trait reinvestment did not show any main effects or

Table 1. Descriptive statistics (mean [SD]) for state anxiety and recovery, in the no-audience and audience condition and across the execution-only and dynamic task context.

	Execution-only			Dynamic		
	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)
CSAI2R questionnaire (1–4)						
No-audience	1.97 (.66)	1.86 (0.68)	2.11 (0.72)	1.96 (.74)	1.74 (0.75)	2.23 (0.75)
Audience	2.01 (.58)	1.86 (0.63)	2.14 (0.57)	1.99 (.59)	1.89 (0.70)	2.11 (0.54)
HPHEES questionnaire (1–10)						
Recovery (item 1)						
No-audience	7.47 (1.60)	8.29 (1.70)	6.71 (1.25)	7.47 (2.03)	7.14 (2.54)	8.14 (1.21)
Audience	6.73 (2.60)	6.71 (3.25)	7.29 (1.60)	7.27 (1.62)	7.43 (2.37)	7.14 (0.69)
Fatigue (items 2–6)						
No-audience	31.93 (6.51)	29.57 (5.62)	34.00 (7.42)	28.27 (7.23)	28.00 (8.83)	27.43 (5.74)
Audience	30.93 (6.81)	28.29 (6.21)	31.86 (6.01)	30.93 (5.31)	29.14 (5.01)	31.71 (5.28)

interactions (p's > .33). In short, presence of an audience did not result in a significant increase in (self-perceived) state anxiety.

The ANOVA conducted on the adapted HPHEES recovery score (Item 1), indicated no significant main effect of audience, $F(1,14) = 1.56$, $p = .23$, $\eta p^2 = .10$, no significant main effect of task context, $F(1,14) = 0.42$, $p = .53$, $\eta p^2 = .03$, and no significant audience × task context interaction, $F(1,14) = 0.32$, $p = .58$, $\eta p^2 = .02$. The ANOVA conducted on the adapted HPHEES fatigue score (Items 2–7), indicated no significant main effect of audience, $F(1,14) = 0.72$, $p = .41$, $\eta p^2 = .05$, no significant main effect of task context, $F(1,14) = 1.74$, $p = .21$, $\eta p^2 = .11$, and no significant audience × task context interaction, $F(1,14) = 2.32$, $p = .15$, $\eta p^2 = .14$. Trait reinvestment did not show any main or interaction effects (p's > .06). In short, there was no significant impact of fatigue throughout the study.

Conscious motor processing

Means and standard deviations for conscious motor processing are displayed in Table 2.

The ANOVA conducted on skill-focused dual-task accuracy indicated no significant main effect of audience, $F(1,13) = 2.97$, $p = .11$, $\eta p^2 = .19$, no significant main effect of task context, $F(1,13) = 0.73$, $p = .41$, $\eta p^2 = .05$, and no significant audience × task context interaction effect, $F(1,13) = 0.07$, $p = .80$, $\eta p^2 = .01$. Trait reinvestment interacted significantly with task context, $F(1, 11) = 5.03$ $p = .047$, $\eta p^2 = .003$. Pairwise comparisons revealed that for high reinvestors, but not low reinvestors ($p = .38$), skill-focused dual-task responses were more accurate in the execution-only task context compared to the dynamic task context ($p = .04$). No other effects were significant (all p's > .10).

The ANOVA conducted on state MSRS scores indicated no significant main effect of audience, $F(1,14) = 0.64$, $p = .44$, $\eta p^2 = .04$, no significant main effect of task context,

Table 2. Descriptive statistics (mean (SD)) for state conscious motor processing measures, in the no-audience and audience conditions and across the execution-only and dynamic task context.

	Execution-only			Dynamic		
	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)
Skill-focused dual-task						
% Correct responses						
No-audience	73.52 (16.32)	73.97 (13.41)	79.27 (8.97)	70.56 (18.36)	77.02 (16.38)	69.74 (16.79)
Audience	69.32 (19.11)	68.83 (17.89)	74.28 (18.07)	67.20 (19.35)	73.14 (19.65)	66.45 (17.33)
State Movement Specific Reinvestment Scale						
MSRS total score (7–42)						
No-audience	27.40 (5.85)	23.57 (3.21)	31.14 (6.01)	26.60 (6.50)	22.57 (4.69)	30.29 (6.40)
Audience	25.53 (6.55)	21.14 (5.64)	29.86 (4.88)	26.87 (6.19)	22.71 (4.54)	30. 86 (5.46)
CMP subscale (4–24)						
No-audience	19.20 (2.83)	17.43 (2.82)	20.71 (1.98)	18.27 (4.17)	17.29 (4.03)	19.29 (4.68)
Audience	17.60 (3.50)	15.86 (3.85)	19.29 (2.63)	18.07 (3.95)	16.00 (4.28)	19.86 (2.97)
MSC subscale (3–18)						
No-audience	8.20 (4.00)	6.14 (2.67)	10.43 (4.39)	8.33 (3.64)	5.29 (2.36)	11.00 (2.52)
Audience	7.93 (3.61)	5.29 (2.36)	10.57 (2.94)	8.80 (3.34)	6.71 (2.14)	11.00 (3.27)

$F(1,14) = 0.29$, $p = .60$, $\eta p^2 = .02$, and no significant audience × task context interaction, $F(1,14) = 4.51$, $p = .05$, $\eta p^2 = .24$. Finally, a significant main effect of trait reinvestment was observed, with high reinvestors showing significantly higher state MSRS scores than low reinvestors. $F(1,12) = 11.04$, $p = .01$, $\eta p^2 = .48$. Further analyses considering the state CMP and MSC subscales determined that high reinvestors scored higher than low reinvestors on the MSC subscale ($p = .003$), but not (or only marginally so) on the CMP subscale ($p = .07$). No other effects were significant (all p's > .07).

Penalty shooting performance

The ANOVA conducted on penalty shooting accuracy indicated no significant main effect of audience, $F(1,14) = 0.20$, $p = .66$, $\eta p^2 = .01$, a significant main effect of task context, $F(1,14) = 7.85$, $p = .014$, $\eta p^2 = .36$, and no significant interaction, $F(1,14) = 0.40$, $p = .54$, $\eta p^2 = .03$. Follow-up testing on the significant main effect of task context determined that accuracy was higher in the execution-only task context compared to the dynamic task context ($p = .01$; see Table 3). Trait reinvestment did not show any main or interaction effects (p's > .10).

The ANOVA conducted on reaction times indicated no significant main effect of audience, $F(1,14) = 0.25$, $p = .63$, $\eta p^2 = .02$, no significant main effect of task context, $F(1,14) = 0.75$, $p = .40$, $\eta p^2 = .05$, and no significant audience × task context interaction, $F(1,14) = 0.66$, $p = .43$, $\eta p^2 = .05$. Trait reinvestment analyses revealed a significant trait reinvestment × audience × task context interaction $F(1,12) = 11.13$ $p = .01$, $\eta p^2 = .48$. Pairwise comparisons revealed that in the dynamic task context (but not in the execution-only task context), high reinvestors (but not low reinvestors; $p = .22$) responded significantly faster under high pressure compared to low pressure ($p = .03$). No other effects were significant (all p's > .24).

The ANOVA conducted on movement times indicated no significant main effect of audience, $F(1,14) = 1.03$, $p = .33$, $\eta p^2 = .07$, no significant main effect of task context, $F(1,14) = 2.94$,

Table 3. Descriptive statistics (mean (SD)) for penalty shooting accuracy, reaction times and movement times, in the no-audience and audience conditions and across the execution-only and dynamic task context.

	Execution-only			Dynamic		
	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)
Penalty shooting accuracy						
% targets hit						
No audience	63.37 (12.07)	65.47 (12.40)	60.51 (12.90)	59.79 (14.92)	65.40 (16.15)	52.68 (12.03)
Audience	65.88 (15.62)	69.26 (7.35)	60.79 (21.15)	60.00 (14.75)	62.05 (12.94)	58.04 (18.19)
Reaction times (s)						
No audience	0.62 (0.14)	0.64 (0.13)	0.56 (0.11)	0.65 (0.12)	0.65 (0.13)	0.62 (0.09)
Audience	0.63 (0.12)	0.62 (0.10)	0.60 (0.11)	0.63 (0.13)	0.68 (0.09)	0.56 (0.14)
Movement times (s)						
No audience	1.65 (0.16)	1.60 (0.18)	1.69 (0.12)	1.65 (0.23)	1.70 (0.33)	1.58 (0.09)
Audience	1.76 (0.23)	1.73 (0.29)	1.79 (0.18)	1.62 (0.20)	1.64 (0.23)	1.61 (0.21)

Table 4. Descriptive statistics (mean (SD)) for state conscious motor processing measures, in the no-audience and audience conditions and across the execution-only and dynamic task context.

	Execution-only			Dynamic		
	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)	Total sample M (SD)	Low reinvestors M (SD)	High reinvestors M (SD)
Stopping success						
% overall stopping success						
No audience	n/a	n/a	n/a	43.45 (30.54)	55.55 (39.03)	28.63 (12.91)
Audience	n/a	n/a	n/a	44.10 (36.11)	44.05 (41.74)	46.82 (35.13)

$p = .11$, $\eta p^2 = .17$, and no significant audience × task context interaction, $F(1,14) = 2.29$, $p = .15$, $\eta p^2 = .14$. Trait reinvestment did not show any main or interaction effects (p's > .10).

Stopping success

The ANOVA conducted on stopping success revealed no significant main effect of audience, $F(1,14) = 0.01$, $p = .93$, $\eta p^2 = .001$, a significant main effect of stop time, $F(3,42) = 27.56$, $p < .001$, $\eta p^2 = .66$, and no significant audience × task context interaction, $F(3,42) = 1.00$, $p = .41$, $\eta p^2 = .07$. Follow-up testing on the significant main effect of stop time confirmed that stopping success decreased with increasing stop time (all p's < .03). Finally, trait reinvestment interacted significantly with audience, $F(1,12) = 6.80$, $p = .023$, $\eta p^2 = .36$. Pairwise comparisons revealed that for high reinvestors, but not low reinvestors ($p = .18$), stopping success was significantly higher in the audience compared to the no-audience condition ($p = .04$; see Table 4). No other effects were significant (all p's > .12).

Mediation analysis

Presence of an audience did not lead to changes in conscious motor processing or performance, thus basic assumptions for undertaking mediation analyses were violated and mediation analyses were not performed (MacKinnon et al., 2007).

Discussion

The current study sought to examine the impact of pressure on conscious motor processing and performance during an adapted “stop-and-go” penalty shooting task, in order to determine whether observed effects of conscious motor processing in “execution-only” contexts may extend to more “dynamic” performance contexts. It was hypothesised that presence of an audience would lead to increased conscious motor processing and decreased penalty shooting performance (Hypothesis 1), that conscious motor processing and penalty shooting performance would be lower in the dynamic context than in the execution-only context (Hypothesis 2), and that conscious motor processing would mediate effects of pressure on performance in the execution-only but not (or less so) in the dynamic task context (Hypothesis 3). Finally, it was hypothesised that effects of pressure on conscious motor processing and performance would be influenced by trait reinvestment, with high trait reinvestors engaging more in conscious motor processing and being more impacted by pressure than low trait reinvestors (Hypothesis 4).

Hypothesis 1: Effects of pressure on conscious motor processing and performance

Penalty shooting performance, conscious motor processing, and stopping success (i.e., response inhibition) were unaffected by the presence of audience. Despite adhering to previously successful methods for increasing observational pressure, by utilising a small audience (e.g., Mesagno et al., 2012), manipulation checks determined that – at a subjective level – participants felt relatively unaffected, with no significant changes observed in self-reported state anxiety scores (i.e., CSAI-2R scores). Based on the Theory of Reinvestment (Masters, 1992; Masters & Maxwell, 2008), presence of an audience was expected to increase participants' self-awareness and induce conscious control of movement. However, neither the state version of the Movement Specific Reinvestment Scale (MSRS; subjective) nor the skill-focused dual-task (objective) revealed evidence of significant changes in conscious motor processing. Possibly, the mere presence of an audience – despite earlier findings (Mesagno et al., 2012) – was not potent enough as a manipulation. Especially considering the players soccer experience level, and higher levels of perceived pressure may be required to effectively induce conscious motor processing. Alternatively, considering their trait reinvestment scores, participants in the current study, overall, may not have had a strong enough inclination towards engaging in conscious motor processing. In considering the current findings, it is important to note that – while most studies support a positive association between pressure and conscious motor processing, and a negative association between pressure and performance – there are several studies that found no effect or an opposite effect (for review see Sullivan et al., 2022). To progress insight into potentially modulating factors, future studies should examine the role of pressure intensity and individual differences (e.g., Mosley & Laborde, 2016), for instance trait reinvestment, competitive trait anxiety, and fear of negative evaluation, when investigating the effects of pressure on conscious motor processing and performance.

Hypothesis 2: Influence of task context

In partial support of our hypothesis, introducing the possibility of stopping (i.e., performing in a dynamic task context) resulted in reduced penalty shooting performance. Dynamic task contexts require performers not only to focus on movement execution, but also to monitor for potential cues signalling the requirement to change (or in this case cancel) the initiated course of action. In line with the current findings, a well-established body of literature indicates that introducing the possibility of stopping triggers a more proactive (conservative) response strategy (Hannah & Aron, 2021; Verbruggen & Logan, 2009), changing intrinsic properties of the go-process so that actions can be cancelled effectively in case the situation requires it (Wadsley et al., 2023). Although the attentional costs of proactive control were not reflected in decreased conscious motor processing (as was hypothesised), the accuracy of participants' penalty kicks was affected. Possibly, monitoring for relevant cues in the current context caused participants to increase attention to the goalkeeper (whose movement signalled the requirement to stop), resulting in less attention being available for shooting and an overall decrease in penalty shooting accuracy (cf. Wilson et al., 2009). Future studies could employ mobile eye-tracking techniques to examine whether changes in visual attention explain observed effects of a dynamic task context (e.g., alternative possibilities for action; possible action cancellation) on accuracy and performance in penalty shooting and other far-aiming tasks.

Hypothesis 3: Does conscious motor processing contribute to performing under pressure?

Since presence of an audience did not influence conscious motor processing or performance, no mediation analyses could be performed to examine whether pressure-induced changes in conscious motor processing influence performance.

Hypothesis 4: Trait reinvestment

Trait reinvestment analyses pointed towards a significant impact of trait reinvestment (Masters et al., 2005). In partial support of our hypothesis, findings confirmed that "high reinvestors" engaged in conscious control to a greater extent than "low reinvestors", with high reinvestors consistently showing higher levels of state reinvestment (as measured with the state MSRS; Masters et al., 2005). Furthermore, in the dynamic task context, high reinvestors had faster reaction times and demonstrated greater stopping success in the presence of an audience, compared to no audience. Since high reinvestors initiated their run-up earlier in the presence of an audience, but still completed their kick at the same time, they effectively spent more time in the execution phase of movement. Longer execution times for high reinvestors are typical across high-pressure contexts (e.g., Malhotra et al., 2012) and are thought to be reflective of "step-by-step" deliberate control. Finally, in the audience condition, high reinvestors significantly improved their inhibitory performance. This is in line with results from Park et al. (2020), who investigated inhibition function amongst a student sample of high- and low reinvestors and concluded that higher propensity for reinvestment was associated with superior inhibition function. Possibly, circumstances that trigger high reinvestors to engage in step-by-step control of movement (such as presence of an audience), make it easier for these individuals to cancel a movement if the situation requires this. Taken together, the findings confirm that trait reinvestment is an important factor to consider in the effects of pressure on conscious motor processing and performance. Future studies are required to replicate the current findings in a larger sample.

Strengths, limitations, and future directions

The current study had several strengths, such as the inclusion of both objective and subjective means of assessing conscious motor processing. Furthermore, power calculations based on previous work (e.g., Cooke et al., 2011; Lo et al., 2019) indicate that the sample size for the main analyses was sufficient. There are, however, some limitations. First, while previous studies successfully utilised presence of an audience to manipulate pressure in sport tasks (e.g., Mesagno et al., 2012; Navarro et al., 2012), participants in the current study reported no significant differences in (self-reported) state anxiety between audience conditions. While it is uncertain how much pressure is needed to reliably induce conscious motor processing (Masters & Maxwell, 2008), future studies may want to consider further augmenting their pressure manipulation, for example, by also including monetary incentives and/or a competition aspect (see Masters, 1992, for an example). Second, the skill-focused dual-task that was implemented to assess conscious motor processing required participants to attend to an auditory tone on all go-trials (i.e., as in Gray, 2004). Arguably, this may have inflated baseline levels of skill focus and limited the extent to which conscious motor processing could increase further. Furthermore, it is uncertain whether the probe question that was used (i.e., did the tone come before or after foot-ball contact) effectively targeted an aspect of skill execution that participants would normally attend to under pressure. Still, covariate analyses confirmed that high reinvestors exhibited higher state MSRS scores than low reinvestors, thereby supporting the current measure's validity. Finally, in distinguishing between low and high trait reinvestors, the sample size for our covariate analyses is low. Findings pertaining to these analyses, therefore, should be interpreted with caution and future research is required to replicate observations in a larger sample.

Conclusion

The current study examined effects of the presence of an audience on conscious motor processing and performance in an adapted "stop-and-go" penalty shooting task. Specifically, we investigated whether pressure-induced changes in conscious motor processing, as observed in "execution only" contexts, influence performance in "dynamic" task contexts, where initiated actions may need to be cancelled or changed in response to newly available information (e.g., the actions of an opponent). Introducing a dynamic task context resulted in reduced penalty shooting accuracy. However, engagement in conscious motor processing, performance, and stopping success were unaffected by the presence of an audience. Covariate analyses, investigating associations between conscious motor processing and performance under pressure, determined that individuals with a high propensity for reinvestment engaged more in conscious motor processing and were better able to inhibit responses (action cancellation) under pressure, potentially uncovering an advantage of going about movement execution in a step-by-step fashion. Further studies of conscious motor processing in dynamic task contexts are required and, alongside performance pressure, should consider the influence of personality characteristics (e.g., trait reinvestment) in their experimental design.

Note

1. To consider the influence of other trait variables, additional covariate analyses were performed including trait decision reinvestment (DSRS scores) and trait anxiety (SCAT scores). Findings did not reveal independent main effects, nor did they significantly change outcomes of the reported (main) analyses.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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