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Conscious motor control impairs attentional processing efficiency during precision stepping

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ABSTRACT

Background: Current evidence suggests that fall-related anxiety can impair attentional processing efficiency during gait in both young and older adults, reducing the cognitive resources available for carrying out concurrent tasks (i.e., holding a conversation whilst walking or planning the safest route for navigation).

Research question: It has been suggested that fall-related anxiety may impair processing efficiency by directing attention ‘internally’, towards consciously controlling and monitoring movement. The present study aimed to evaluate this interpretation.

Methods: Fifteen healthy young adults performed a precision stepping task during both single- and dual-task (completing the stepping task while simultaneously performing an arithmetic task), under three conditions: (1) Baseline; (2) Threat (walking on a platform raised 1.1 m above ground), and; (3) Internal focus of attention (cues/instructions to direct attention towards movement processing).

Results: We observed significantly greater cognitive dual-task costs (i.e., poorer performance on the arithmetic task) during Threat compared to Baseline, with the greatest costs observed in individuals reporting the highest levels of Threat-induced conscious motor processing. Significantly greater cognitive dual-task costs were also observed during the Internal condition, confirming the assumption that consciously attending to movement reduces cognitive resources available for carrying out a secondary task during gait. These results were accompanied with significantly poorer stepping accuracy in dual-task trials during both Threat and Internal.

Significance: These findings support previous attempts to rationalise attentional processing inefficiencies observed in anxious walkers as being a consequence of an anxiety-induced internal focus of attention.

1. Introduction

It is widely accepted that the control of posture and gait requires cognitive input [1]. Much in the same way that anxiety can disrupt attentional processing, and subsequent performance, on other tasks requiring cognitive input (such as analogical problem solving) [2,3], research demonstrates that fall-related anxiety can compromise attentional processing efficiency during gait in both young [4] and older adults [4,5]. These inefficiencies can reduce the cognitive resources available for carrying out concurrent processes necessary for safe locomotion, such as feedforward movement planning [6].

Fall-related anxiety may impair processing efficiency by virtue of walkers allocating attention ‘internally’ towards movement-specific processes [4]. A causal relationship between fall-related anxiety and increased conscious movement processing has been documented in both young adults standing at height [7–9] and older adults when walking [10]. Cross-sectional research also implicates an internal focus as increasing attentional demands of walking [10,11], subsequently reducing cognitive resources available for carrying out concurrent processes. However, a causal relationship between the adoption of an internal focus and compromised attentional processing efficiency during gait is yet to be evaluated.

In the current study we aimed to investigate whether fall-related anxiety can compromise attentional processing efficiency during gait, as a consequence of walkers allocating attention towards movement-specific processes. To achieve this aim, we sought to experimentally induce both fall-related anxiety and conscious movement processing (independent of anxiety) and answer whether an internal focus of attention can impair attentional processing efficiency during gait in a manner similar to anxiety. Young adults performed a precision stepping task during both single- and dual-task, under three conditions: Baseline; Threat, and; Internal focus of attention. We predicted that: (1) Attentional processing efficiency would be impaired during Threat (indicated by greater cognitive dual-task costs); (2) These inefficiencies

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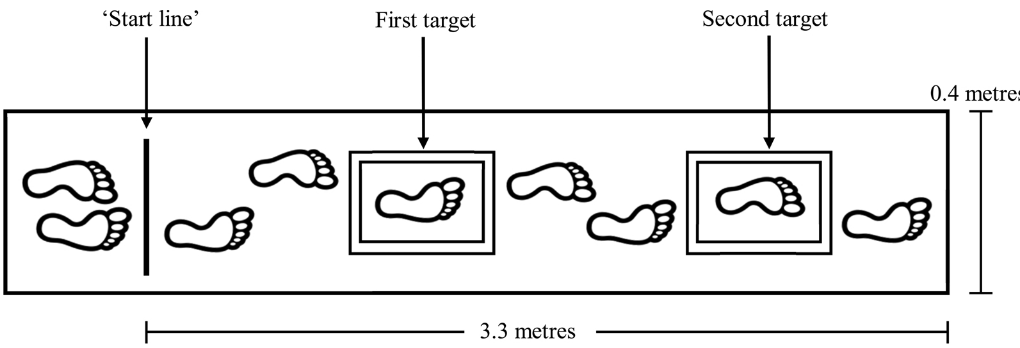

Fig. 1. Schematic diagram of the walkway and precision stepping task. The foam targets had a border width and height of 4 cm (i.e., the foam border was 4 cm wide and raised 4 cm from the walkway). The inside area of the target was 19 cm × 41.5 cm (width and length, respectively).

would be associated with greater internal focus, with the greatest costs observed in individuals reporting the highest levels of conscious movement control, and; (3) Significant processing inefficiencies would also be observed when manipulating attentional focus during the Internal condition (independent of anxiety).

2. Methods

2.1. Participants

Fifteen young adults (male/female: 8/7; mean ± SD age: 25.47 ± 2.42 years) were recruited from postgraduate courses at the lead institution. Inclusion criteria required participants to be free from any musculoskeletal, visual, auditory or speech problems. Ethical approval was obtained by the local institutional ethics committee.

2.2. Procedure

Participants walked at a self-determined pace along a wooden walkway and stepped into two foam targets (see Fig. 1) comprising raised borders (border width and height = 4 cm). The inside area of the target was 19 cm × 41.5 cm (width × length). Participants were instructed to "step into the middle of the target, placing the mid-foot marker (see Section 2.4) as close to the centre of the target as possible". Participants were permitted to step into each target with whichever foot they wished. At the start of each trial, participants stood behind a 'start line' and began walking upon an auditory 'go' tone.

Participants completed walks under three conditions: Baseline; Threat, and; Internal. Baseline involved participants completing the protocol at ground level. Threat involved participants completing the protocol while the walkway was elevated 1.1 m above ground, in the absence of a safety harness. Internal required participants to complete the protocol at ground level, while focusing their attention internally towards movement. To achieve this, participants were informed that after each trial in this condition, they would be asked a question relating to their movement. These questions were comparable to those used previously to determine 'internal awareness' [10,12] and were designed to encourage the adoption of an internal focus throughout the duration of the trial. Examples included: "What foot did you step into of the first/second target with?" and "How many steps did you take to complete the trial?" Participants were 'informed' that any trials in which they answered incorrectly would be repeated. While this deception was used to ensure engagement with the manipulation, response accuracy was recorded. Four participants provided an incorrect answer for 1 trial, respectively.

Participants completed 10 trials per condition, split across two 5-trial blocks. The presentation order of conditions was randomised, however participants only ever completed 5 trials in one condition, before being presented with a different condition. Target locations were rearranged after every block to prevent familiarisation. Targets could appear in two randomised locations (first target: either 100 cm or 110 cm from the start line; second target: either 190 cm or 200 cm from the start line).

Trials were completed under both Single-task and Dual-task conditions. Dual-task consisted of walking while concurrently subtracting in 7's from a randomised number between 70 and 90. Participants were presented with the starting number directly prior to the 'go' tone, following which they began to walk and subtract out loud. Participants were instructed to allocate equal attention towards both the walking and arithmetic task [11,13,14]. For each condition, participants completed five Single-task and five Dual-task trials, the order of which was randomised across each condition (each 5-trial block contained a randomised combination of Single- and Dual-task trials).

2.3. Self-reported state psychological measures

Participants rated their fear of falling and state movement-specific reinvestment (as a measure of conscious movement processing) after each block of 5-trials. To assess fear of falling, participants were asked: "Using the following scale, please rate how fearful of falling you felt during the past five trials" [8]. This scale ranged from 0% (not at all fearful) to 100% (completely fearful). State movement-specific reinvestment was measured using a shortened version of the Movement Specific Reinvestment Scale (MSRS) [15]. This 4-item questionnaire consisted of two 2-item subscales: conscious motor processing, i.e., 'movement control' (state-CMP; e.g., "I am always trying to think about my movements when I am doing this task") and movement self-consciousness, i.e., 'movement monitoring' (state-MSC; e.g., "I am concerned about my style of moving when I am doing this task"). Items were rated on a 6-point Likert scale (1 = *strongly disagree*; 6 = *strongly agree*). A shortened 4-item version of the MSRS has been used previously by Young et al. [10].

2.4. Attentional processing (dual-task assessments)

To quantify participants' ability to execute two tasks concurrently, we calculated dual-task costs (DTCs) according to the customary formula [16]:

Cognitive DTC (%) = 100 * (single-task score − dual-task score)/single-task score

Motor DTC (%) = 100 * (dual-task score − single-task score)/single-task score

Thus, higher DTCs reflect decreased performance under dual-task. Raw performance values are presented in Table 1.

2.4.1. Cognitive DTCs

Cognitive performance was defined as the number of correct arithmetic calculations verbalised. Dual-task scores were calculated