Title: The influence of anxiety and attentional focus on visual search during adaptive gait

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Abstract

Research demonstrates the multifaceted influence of fall-related anxiety on postural control. However, very little work has sought to identify psychological mechanisms through which anxiety influences movement planning and jeopardises balance safety. Experiment 1 demonstrates evidence of a causal link between postural threat and altered visual search during adaptive gait, indicative of both increased on-line control of stepping movements (at the expense planning future stepping actions), and a gaze bias towards threats to balance. Participants also reported allocating greater attention towards both conscious movement processing and external threatening stimuli. Experiment 2 sought to further evaluate possible attentional factors underpinning changes observed in Experiment 1. Here, participants completed the same task under conditions of (i) internal focus of attention, and (ii) reduced resources available for movement planning. Similar to when anxious, participants displayed increased on-line control of stepping—at the expense of feedforward planning—when focusing attention ‘internally’. However, no such changes were observed during conditions of reduced resources. We consequently interpret altered patterns of visual search observed during anxious gait to represent both a gaze bias towards threats to balance (i.e., increased reliance on the stimulus-driven attentional system) and the subsequent conscious processing of movement to prevent a fall.

Key words: Anxiety; Fear of falling; Internal focus; Attention; Attentional control; Gaze behaviour; Visual search; Locomotion; Gait

Public significance statement

This research demonstrates evidence in healthy controls of a causal link between fall-related anxiety and maladaptive patterns of visual search previously observed in older adults at high risk of falling—specifically, reduced visual previewing of future stepping constraints. We interpret these changes to indicate that fall-related anxiety may reduce safety while walking by limiting an individual's ability to plan future stepping movements. Consequently, aside from the theoretical implications of this work, these findings could contribute to the development of tools designed to both predict and prevent falls in older adults and also monitor their recovery during rehabilitation.

1. Introduction

Research demonstrates the varied and largely detrimental effects that anxiety can have on perceptual-motor performance (e.g., taking a penalty kick during a world-championship final [Hardy, 1996; Nieuwenhuys & Oudejans, 2012]). Research from the domain of sport psychology highlights how anxiety can jeopardise both motor coordination and the extent to which performers visually scan their environments prior to, and during, movement execution (for reviews, see Janelle, 2002; Nieuwenhuys & Oudejans, 2012; Vickers, 2007). Typically, anxious performers display less efficient visual scanning behaviours (Janelle, 2002). They are more easily distracted by task-irrelevant information (Nieuwenhuys & Oudejans, 2012; Williams & Elliott, 1999) and they focus on task-relevant information for shorter durations (Nibbeling, Oudejans, & Daanen, 2012; Wilson, Vine, & Wood, 2009); behaviours strongly correlated with poorer execution of subsequent movements (Nibbeling et al., 2012; Vickers, 2007; Wilson et al., 2009).

Locomotion, particularly in complex environments, is predominantly a visually guided action (Chapman & Hollands, 2006a; Matthis, Barton, & Fajen, 2015, 2017; Matthis & Fajen, 2013; Patla, 1991). Therefore, the visual-perceptual processes necessary for effective control of this movement (i.e., visually scanning one’s environment to acquire information necessary to avoid a trip-hazard) may be susceptible to similar anxiety-related disruptions as those observed during visually guided sporting motor tasks. Indeed, researchers have suggested that fall-related anxiety may impair visual search behaviours during locomotion (Staab, 2014; Young & Williams, 2015). Despite this, the majority of research within the field of gait and posture focuses on how fall-related anxiety impacts cognitive processing and motor output during locomotion (e.g., Gage, Sleik, Polych, McKenzie, & Brown, 2003; Uemura et al., 2012; Young, Olonilua, Masters, Dimitriadis, & Williams, 2016), rather than considering how processes related to the acquisition of sensory information (i.e., altered eye movements) may also contribute to these changes.

Research highlights that older adults at a high-risk of falling display altered patterns of visual search during adaptive gait (Chapman & Hollands, 2006b), including behaviours causally linked to increased stepping errors and reduced safety (Young & Hollands, 2010). As a result, the identification of underlying causal factors contributing to these altered patterns of visual search will allow for the development of strategies to target these potentially dangerous behaviours.

1.1. Visual control of locomotion

Research demonstrates a robust spatiotemporal coupling between eye and foot movements during adaptive locomotion (Hollands & Marple-Horvat, 2001; Hollands, Marple-Horvat, Henkes, & Rowan, 1995), indicating that visual information is sampled during specific phases of the stepping cycle. Typically, individuals will transfer their gaze towards a target at the start of the stance phase prior to initiating the step towards this stepping constraint, maintaining this fixation until shortly before the step is completed (i.e., 'on-line' visual control). However, rather than relying solely on on-line visual information to guide stepping trajectory, safe and energetically efficient locomotion requires visual information to be used to also plan movement in a 'feedforward' manner. For example, while visual information can be used to make rapid, on-line adjustments once a step has been initiated (Reynolds & Day, 2005), locomotion is likely to be more stable if movements are guided through feedforward control rather than having to rely on making unexpected changes to foot trajectory mid-step (Matthis & Fajen, 2014). Similarly, precision steps are likely to be more accurate when controlled in a feedforward, rather than purely on-line, manner (Chapman & Hollands, 2006a).

As we walk through our cluttered world, we build a visual-spatial map of our environment (Zettel, Scovil, McIlroy, & Maki, 2007). Feedforward visual sampling allows not only for the identification of potential threats to balance, but also for the subsequent planning and execution of stepping behaviours necessary to avoid tripping. Recent research by Matthis and colleagues describes a ‘critical phase’ for visual control of human locomotion (Matthis et al., 2015, 2017; Matthis & Fajen, 2014). These findings suggest that while walkers *can* use on-line vision to control precision stepping, visual information from at least two step-lengths ahead is needed to *effectively* navigate a stepping constraint. Such feedforward planning allows for the mechanical state of the body to be adjusted to optimise the trajectory of both the centre of mass and stepping leg, prior to the initiation of the precision step itself—maximising stability and reducing the likelihood of having to produce a potentially destabilising mid-step adjustment. Consequently, failing to acquire visual information relating to a stepping constraint prior to this critical phase will likely reduce safety during locomotion by virtue of the walker having reduced ability to avoid an obstacle or step accurately onto a target.

1.2. Disrupted visual search when anxious about falling

It has been suggested that fall-related anxiety may disrupt visual search during gait and potentially compromise the important processes necessary for ensuring safety during locomotion (Staab, 2014; Young & Williams, 2015). For example, when standing on an elevated balcony (raised 20 metres above ground), individuals fearful of heights will restrict both their head movements and visual exploration of their environment, instead ‘freezing’ their gaze on the horizon (Kugler, Huppert, Schneider, & Brandt, 2013). Similar patterns of results were also presented when fearful individuals traversed this elevated balcony (Kugler, Huppert, Eckl, Schneider, & Brandt, 2014), with gaze fixated predominantly on the “ground nearby in the heading direction” (Kugler et al., 2014, pp. 8). As optimal feedforward movement planning requires two step lengths worth of visual information (Matthis & Fajen, 2014), this limited visual search behaviour will likely reduce safety during adaptive locomotion (Brandt, Kugler, Schniepp, Wuehr, & Huppert, 2015). However, as the task employed by Kugler and Colleagues (2014) did not involve the navigation of stepping constraints, but rather walking on an even flat surface, there would have been little negative consequence of reduced feedforward movement planning.

Similar reductions in visual exploration have, however, been observed in anxious older adults when approaching a target followed by a series of obstacles (Young, Wing and Hollands (2012). Here, older adults deemed to be at a low risk of falling displayed a 'proactive' pattern of visual exploration, fixating, and transferring their gaze between, subsequent stepping constraints. In contrast, high-risk older adults directed their gaze predominantly towards the proximal stepping target and displayed reduced visual previewing of future stepping constraints. These high-risk older adults subsequently transferred their gaze away from this initial stepping target significantly earlier (i.e., before the step into the target had been completed), in order to fixate the following constraints; presumably because they had failed to acquire this visual information during the approach to the initial stepping constraint. The magnitude of this premature gaze transfer was associated with increased stepping errors into this target—indicating reduced safety. As the high-risk older adults also reported significantly greater levels of state anxiety, the authors speculated that observed reductions in visual previewing and associated stepping errors were a consequence of heightened fear of falling. However, as these authors did not specifically manipulate anxiety, but rather task complexity which resulted in heightened fear of falling, one must be cautious when attributing these changes directly to fall-related anxiety and not, for example, group differences in ability to navigate the more challenging stepping task.

1.3. Theoretical accounts of altered visual search

As with other forms of perceptual-motor performance, two main dichotomising theoretical explanations have been proposed to account for anxiety-related alterations in visual search during gait (Young & Williams, 2015). *Distraction* theories postulate that anxiety disrupts performance by directing attention towards threatening, task-irrelevant cues, thus reducing the attentional resources available for processing task-relevant information (Wine, 1971). These task-irrelevant cues can be either *internal* (worries or disturbing thoughts relating to the consequences of failure) or *external* (i.e., threatening task-irrelevant distractors, such as the crowd behind a goal when taking a penalty kick). In contrast, *self-focus*—or, *explicit-monitoring* (Beilock & Carr, 2001)—theories hold that anxiety leads the performer to direct conscious attention towards monitoring or controlling previously 'automatic' movement processes (Baumeister, 1984). In broad terms, distraction theories suggest that anxiety leads to performance break-down as a result of directing *too little* on-line attention towards movement execution, while self-focus theories postulate that performance decrements are a consequence of directing *too much* on-line attention towards movement.

Distraction perspectives. Providing support for distraction theories, Young and Williams (2015) suggest that anxiety-related reductions in visual exploration may reflect an inability to plan future actions as a result of preferentially processing internal worries. Indeed, a recent case study describes the dramatic changes in visual search behaviours (and subsequent stepping accuracy) in an older adult 2-3 weeks following their first fall; despite no recorded changes in cognitive or physical functioning, with the single exception of increased concerns/worries about falling (Young & Hollands, 2012b). Staab (2014) similarly highlights distraction theories as a potential explanation for anxiety-related changes in visual search during gait. However, rather than implicating internal distracters (such as worries) as an underlying cause of this behaviour, Staab (2014) interprets the aforementioned altered patterns of visual search in anxious older adults to be representative of an attentional bias for external threat-related stimuli—with preferential allocation directed towards upcoming threats to balance.

Self-focus perspectives. In contrast, researchers have also utilised self-focus theories to explain how fall-related anxiety may alter visual search during gait (Uiga, Cheng, Wilson, Masters, & Capio, 2015b; Young & Williams, 2015). Evidence exists for a causal link between fall-related anxiety and heightened conscious movement processing when walking (Ellmers & Young, 2018; Young et al., 2016). As this form of movement execution is characterised by increased on-line movement processing (Jackson, Ashford, & Norsworthy, 2006), it is possible that the reduced visual exploration observed in anxious individuals—whereby gaze is fixated predominantly on the "ground nearby in the heading direction" (Kugler et al., 2014, pp. 8)—is a consequence of the prioritisation of the on-line visual information needed to consciously control/monitor individual stepping movements. Indeed, Beilock and Carr's (2001) theory of explicit monitoring suggests that anxiety "increases the attention paid to skill processes and their *step-by-step* control [emphasis added]" (pp. 701). The question remains if adopting 'step-by-step control' during locomotion occurs at the expense of visually exploring one's environment and planning future stepping actions—although, older adults who control/monitor their walking (characterised by, among other things, a greater awareness of individual foot placement; thus indicating increased on-line processing of individual steps) will often do so at the expense of attending to the environment (Uiga, Capio, Wong, Wilson, & Masters, 2015a).

Integrated perspectives. While research has traditionally focused on the dichotomy between the influence of distraction and self-focus (e.g., Baumeister & Showers, 1986; Beilock & Carr, 2001), recent theoretical developments have led researchers to consider the interplay between these factors. For example, Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007)—and the subsequent update and application of this theory to perceptual-motor tasks, Attentional Control Theory: Sport (ACTS; Eysenck & Wilson, 2016)—posits that anxiety disrupts the balance between the goal-directed ('active' top-down attention influenced by prior experience and knowledge) and stimulus-driven attentional systems ('passive' bottom-up attention driven by salient and threatening stimuli) (Corbetta & Shulman, 2002). As such, anxious individuals are less able to inhibit the diversion of attention away from task-relevant cues towards internal or external task-irrelevant threat-related distractions (as per distraction accounts). Consequently, attention is biased towards "detecting the source of the threat and deciding how to respond" (Wilson, 2008, pp. 195)—with ACTS proposing that anxious individuals may be less able to inhibit such responses from being initiated and/or controlled via potentially disruptive conscious, on-line mechanisms (as per self-focus accounts).[1] Similarly, in *the integrated model of anxiety and perceptual-motor performance*, Nieuwenhuys and Oudejans (2012) propose that anxious performers will direct preferential attention towards task-irrelevant distractions. However, this model argues that during perceptual-motor tasks typically governed by 'automatic', lower-level processes (such as locomotion), such task-irrelevant distractions may also include the direction of attention towards movement execution (given that consciously processing such information is not typically required for successful performance). This assumption is supported by research demonstrating that consciously processing movement during gait can 'distract' attention away from other task-relevant processes, such as extracting relevant visual information from one's walking environment (Uiga et al., 2015b).

Despite these contrasting theoretical accounts, little attempt has been made to explore specific psychological factors underpinning previously observed anxiety-related changes in visual search during locomotion—with researchers instead retrospectively applying

[1] While ACT is often classified as a distraction model (e.g., Christensen, Sutton, & McIlwain, 2015; Nieuwenhuys & Oudejans, 2012), given the recent theoretical developments associated with ACTS which allow for both distraction and self-focus factors to be contextualised within this model, we thus view this theory as an integrated model.

psychological theory to existing findings (i.e., Young & Williams, 2015). Understanding mechanisms that underpin these changes is the necessary first step in designing interventions aimed at minimising the negative impact of fall-related anxiety.

1.4. The present experiments

The emerging body of literature documenting anxiety-related changes in visual search behaviours during adaptive gait (e.g., Kugler et al., 2014; Young & Hollands, 2012; Young et al., 2012) are described above. However, to date, this previous research has only studied clinical populations suffering from co-morbidities likely to confound observations (e.g., visual intolerances to height [Kugler et al., 2014] or age-related deficits in visuomotor processing [Young et al., 2012]). Furthermore, as noted in previous sections, the conclusions drawn from this research are limited, on the basis of either featuring simple locomotive tasks requiring limited feedforward planning (Kugler et al., 2014) or failing to directly manipulate fall-related anxiety (Young et al., 2012). Additionally, while this research offers a preliminary account of *possible* anxiety-related changes in behaviour, these studies were not designed to provide a mechanistic description of the potential psychological/attentional factors underpinning these alterations. As such, the methodologies utilised, the variables assessed, and the conclusions drawn from this previous work are insufficient to conceptualise these behaviours within the context of distraction, self-focus/explicit monitoring, or integrated perspectives.

Experiment 1 aimed to evaluate a possible causal link between fall-related anxiety and altered patterns of visual search during a precision stepping task in a healthy young adult ‘model’ unaffected by countless confounding factors related to either age or clinical disorders. Importantly, the stepping task was designed to require feedforward movement planning, with gaze behaviour variables designed to test predictions presented by different theoretical perspectives. In addition, owing to the difficulties associated with attempting to theoretically interpret alterations in gaze behaviour, a verbal reports protocol was employed to further explore how anxiety-related changes in attentional processing may be associated with altered visual search. For example, while we may observe participants fixating a particular area of the walkway for longer durations when anxious about falling, it is difficult to assign theoretical meaning to such change alone. However, if participants are observed fixating stepping constraints for significantly longer durations as a result of an anxiety-related bias for external threat-related stimuli, we would thus expect verbal reports to indicate that these constraints were indeed interpreted as threats to balance. Experiment 2 then sought to further evaluate possible attentional factors underpinning changes in visual search observed in Experiment 1. Here, participants completed the same task under conditions of both: (1) an internal focus of attention and, (2) reduced cognitive resources available for movement planning.

The relationship between fear of falling and increased fall-risk is well documented (Friedman, Munoz, West, Rubin, & Fried, 2002; Hadjistavropoulos, Delbaere, & Fitzgerald, 2011; Young & Williams, 2015). In both experiments, therefore, we sought to advance our understanding of how fall-related anxiety can influence movement planning and jeopardise balance safety during locomotion.

2. Experiment 1

Experiment 1 compared patterns of visual search, as well as changes in attentional focus (through a verbal report protocol), during a precision stepping task varying in the degree of postural threat. We predicted that under conditions of postural threat, participants would display patterns of visual search supportive of distraction theories, rather than either self-focus or integrated perspectives. Specifically, we predicted preferential allocation of attention towards immediate external threats at the expense of planning future stepping actions (thus indicating increased sensitivity for the stimulus-driven, rather than goal-directed, system). Namely, we predicted that participants would display hypervigilance (i.e., rapid visual fixations) towards the immediate threat to their balance (first stepping constraint). We predicted that participants would then have difficulties disengaging attention away from this immediate external threat, with this reflected in: (1) longer fixation durations on the initial stepping constraint, at the expense of previewing future stepping constraints, (2) reduced fixations made towards subsequent stepping constraints, and (3) reduced gaze transfers between different areas of the walkway (i.e., participants 'freezing' their gaze towards this immediate stepping constraint/threat to balance). We predicted that these changes in visual search would be accompanied by individuals reporting greater attention directed towards both internal (i.e., worries) and external threats (i.e., the stepping constraints), as measured by a verbal report protocol.

While we also predicted that participants would report directing greater attention towards processing movement, we did not expect to observe any patterns of visual search supportive of a self-focus/explicit monitoring account.[2] As such, rather than prioritising the areas of the walkway needed for on-line control of stepping (i.e., freezing gaze towards the immediate walkway one step ahead), we predicted that participants would instead visually prioritise the immediate external threat (the initial stepping constraint)—thus providing support for distraction rather than either self-focus or integrated perspectives (as support for these models would necessitate that participants display increased on-line visual control as either the sole anxiety-related change [self-focus] or in conjunction with preferential attention allocated towards external threats [integrated perspectives]). As this visual search strategy will limit the amount of visual information acquired about subsequent stepping constraints, we predicted that participants would demonstrate an early transfer of gaze away from this

[2] As such, while it is possible to place the hypothesised overall behavioural response to threat within an integrated perspective that unifies distraction and self-focus factors (such as ACT/ACTS), we predict to observe a lack of influence of self-focus factors on gaze behaviour.

initial stepping constraint (i.e., transferring gaze away from the target before the step has been completed) in order to fixate the upcoming stepping constraint, with these early transfers of gaze correlating with the degree of stepping accuracy. We propose that any observation of early gaze transfers would provide further support for distraction theories, as we would expect self-focused individuals relying on on-line vision to guide stepping actions to continue fixating a constraint *until* the step towards it has been completed.

2.1. Methods

2.1.1. Participants

Fourteen young adults (female/male: 8/6; mean ± SD age: 25.86 ± 3.03 years) were recruited from postgraduate courses. Participants were free from any musculoskeletal or neurological impairment. Ethical approval was obtained by the local ethics committee at Brunel University London and the research protocol was carried out in accordance with the principals laid down by the Declaration of Helsinki. All participants provided written and informed consent. Previous research investigating the influence of state anxiety on gaze behaviour has reported effect sizes (partial eta squared) between 0.75 and 0.99 for key, comparable variables (Young et al., 2012). Consequently, a power analysis conducted with G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) determined that between 8 and 13 participants would be required to obtain 80% power (Cohen, 1988).

2.1.2. Procedure

On arrival, participants were fitted with reflective markers placed on the heel and mid-foot of both feet (see Young & Hollands, 2012b), and then with a Mobile Eye-XG portable eye-tracking system (ASL, Bedford, MA). The eye-tracking system records participants' gaze by contrasting the pupil and corneal reflection, allowing the superimposition of a point of gaze crosshair on a video of the environment recorded from a scene camera, which records wirelessly at 30Hz.

The experimental task involved walking at a comfortable, self-determined pace along a wooden walkway (width of 40cm and length of 3.3m) and stepping into two foam rectangular targets. While participants were instructed to walk normally (i.e., steady gait rather than multiple discreet steps), we did not impose strict guidelines on walking speed as we wished to observe changes in visual search without unnatural constraints on their walking behaviour. The 3.3m distance from the start to the end of the walkway used in the present research was comparable to distances used previously by Matthis and Fajen (2014) for similar adaptive gait tasks. The foam targets had raised borders (foam border width and height = 4cm), and the inside area of the target was 19cm x 41.5cm (width and length, respectively'; see Figure 1a). The raised edges were designed to encourage participants to make accurate steps into the target centre by imposing a degree of postural threat, as there would be the chance of a trip occurring if a participant failed to step into the target accurately and caught their foot on a raised edge. Participants were instructed to "step into the middle of the target with the middle of the foot, placing the mid-foot marker as close to the centre of the target as possible." Participants were permitted to step into each target with whichever foot they wished. Prior to the start of each trial, participants stood at the 'start line' (see Figure 1a) with their eyes closed, to prevent them from visually previewing the walkway. When they heard an auditory 'go' tone (played through a speaker located 0.75m to the left of the walkway), participants opened their eyes and commenced the walking task. Prior to commencing data collection, participants completed five familiarisation trials.

Figure 1

Participants completed the protocol under two conditions: (1) Baseline, and (2) Threat. Baseline involved participants completing the protocol at ground level. Threat involved participants completing the protocol while the walkway was elevated 1.1m above the laboratory floor (see Figure 1b). All trials were completed in the absence of a safety harness. Following the completion of the trial, participants stepped either directly away from the walkway (Baseline) or climbed down steps at the end of the walkway (Threat) before walking back to the walkway ‘start line’ to await the next trial. Participants completed one 5-trial block of walks for each condition, with this number of trials selected to avoid participants becoming desensitised to the height manipulation. The presentation order of these conditions was counterbalanced across participants. Target locations were rearranged after each block to reduce familiarisation. Targets could appear in two possible locations (first target: either 1m or 1.1m from the start line of the walkway; second target: either 1.9m or 2m from the start line of the walkway). Target locations were randomised across participants.

2.1.3. Self-reported measures

Directly after each block, participants rated their state fear of falling (as a measure of state-anxiety), reported on a scale ranging from 0% (not at all fearful) to 100% (completely fearful) (Zaback, Cleworth, Carpenter, Adkin, 2015). After each block, a verbal report protocol was also used to investigate anxiety-related changes in attentional focus (Oudejans, Kuijpers, Kooijman, & Bakker, 2011; Zaback, Carpenter, Adkin, 2016). Participants were asked to report both: what they were thinking about while completing the walking task, and; what they were directing their attention towards while completing the walking task. These questions were derived from those used previously by Oudejans et al. (2011) and Zaback et al. (2016). Both questions served the same purpose: To explore how, and where, participants allocated their attention—with the second question included as an additional prompt. As such, answers to each question were analysed together (Oudejans et al., 2011) and coded into one of the following five categories: *Movement processes* (thoughts relating to controlling or monitoring movement, e.g., “I focused on walking slowly”); *Threats to balance* (thoughts about environmental threats to balance, e.g., the raised edges of the stepping targets or the edge of the walkway); *Worries or disturbing thoughts* (e.g. thoughts relating to falling and the potential negative consequences of this); *Self-regulatory strategies* (positive self-talk statements, as well as thoughts adopted to enhance concentration, e.g., “I concentrate on making my breathing more controlled”); and *Task-irrelevant information* (statements unrelated to walking or maintaining balance, e.g., thinking about what one is having for dinner or letting one’s mind wander). These categories were selected on the basis of previous research (Oudejans et al., 2011; Zaback et al., 2016). Examples of categorised verbal report statements are presented in Table 1. Statements were categorised by two independent researchers (authors TJE and WRY), who were blinded to experimental conditions, resulting in 94.1% inter-observer reliability. Any disagreements were discussed until an agreement was met.

Table 1

2.1.4. Motor performance

The following motor performance variables were calculated: (1) Time to complete the walking trial (s), and; (2) stepping error (mm) in both the anterior-posterior (AP) and medio-lateral (ML) planes for the first target. Time to complete the walking trial was calculated from the eye-tracking video acquired from the gaze tracker (sampling at 30Hz), by subtracting the frame in which the ‘go’ tone occurred from the frame in which the participant stepped off the end of the walkway. As participants’ heads were pitched down at an angle that also captured their feet during the step off the walkway, this allowed for a reliable visual inspection of the frame in which the foot contacted either the laboratory floor (Baseline) or the steps (Threat) after the walkway (see Figure 1b). Kinematic data were collected at 100Hz using a Vicon motion capture system (Oxford Metrics, England) and passed through a low-pass butterworth filter with a cut-off frequency of 5 Hz (as per Young et al., 2012). This data was analysed using custom algorithms in MATLAB version 7.11 (MathWorks, Natick, MA). Stepping error was calculated by subtracting the co-ordinate of the mid-foot marker from the co-ordinate of the centre of the target, in AP and ML directions, respectively (Young & Hollands, 2012b; Young et al., 2012). Variables were averaged across each condition. Kinematic data were assigned a randomised code, to allow for blinded analysis.

2.1.5. Gaze behaviour

Visual fixations were defined as a gaze that endured on a single location (≤ 1° visual angle) for 100ms or longer (Patla & Vickers, 1997). Fixation locations were classified as one of four areas of interest (see Figure 1a): (1) first walkway area (the walkway area proximal to the first target); (2) the first target; (3) second walkway area (the walkway between the first and second target), and; (4) the second target. These areas of interest were used to determine the duration spent fixating each location during the approach to the first target. Fixation duration data were normalised to individual trial length by presenting data as the percentage of time spent fixating each area of interest from the point when participants opened their eyes following the ‘go’ tone and made their first fixation, until the time when they stepped into the first target (time of heel contact into the first target, calculated as the maximum vertical acceleration of the heel marker, identified by zero crossing in the jerk profile.). The eye-tracker was synchronised with the motion-capture system through the identification of the frame number in which this ‘go’ tone occurred (as this tone occurred during the first recorded frame of the motion-capture system). As a further measure of visual previewing, the number of fixations made towards the second target (until heel contact into the first target) was also calculated.

Other gaze variables analysed were: Number of gaze transfers between the four areas of interest listed above (calculated as the average number of gaze transfers per second, prior to heel contact in the first target); Time of gaze transfer away from the first target relative to the time of heel contact in that target (ms), with a negative value denoting an early transfer of gaze; Timing (ms) of the first fixation (i.e., delay between the start of the trial and the first fixation onset), and; Location of the first fixation. Number of gaze transfers between the four areas of interest was included to determine any changes in visual exploration (Kugler et al., 2014; Young et al., 2012). The timing and location of the first fixation was included to assess whether fall-related anxiety may induce a hypervigilant visual response (i.e., rapid visual fixations) towards threats—similar to those observed in clinical anxiety disorders (Staab, 2014), and indicating a gaze bias for immediately upcoming threatening stimuli. To determine the location of the first fixation, each area of interest was allocated a number from 1-4 (first walkway area = 1; first target = 2; second walkway area = 3; second target = 4), with lower numbers indicating that the first fixation occurred in an area of interest closer to the walker's feet.

Variables were averaged across the analysed trials for each condition. Trials in which the point of gaze crosshair disappeared for the duration of three frames or more were discarded (see Ellmers, Cocks, Doumas, Williams, & Young, 2016). Participants with a trial-discard rate higher than 40% for either condition were excluded from all analyses (i.e., participants were only included in analyses if they presented three-or-more usable eye-tracking trials per-condition). This procedure resulted in 1 participant's data being excluded. A total of 50 trials were analysed for Baseline (M = 3.85 trials per participant) and 53 trials analysed for Threat (M = 4.08 trials per participant). While attempts were made to blind the assessor to experimental conditions, this was not possible given the between-condition differences in the environmental scene present in the eye-tracking videos.

2.1.6. Statistical Analysis

Self-reported measures. A Wilcoxon test was used to determine whether participants experienced significant changes in state fear of falling during the Threat condition, compared to Baseline. Separate Wilcoxon tests were used to determine the Baseline-Threat change in the number of attentional verbal reports coded for each of the five attentional categories (Zaback et al., 2016). The use of a non-parametric test was deemed necessary here as data were non-normally distributed. For all statistical comparisons, effect sizes are reported as Cohen's *d*, unless the assumption of normality is violated, where effect sizes are reported as $r = Z/\sqrt{N}$ (Fritz, Morris, & Richler, 2012).

Motor performance. Separate paired-samples t-tests were used to determine the Baseline-Threat change in: Time to complete the walking trial and stepping error in both the AP and ML planes for the first target.

Gaze behaviour. Separate paired-samples t-tests were used to determine any Baseline-Threat change in: the number of gaze transfers between the areas of interest; the time and location of the first fixation, and; the duration (presented as a percentage) spent fixating the second walkway area. Separate Wilcoxon tests were used to determine whether there was a significant change during Threat for: percentage of time spent fixating the first walkway area; percentage of time spent fixating the first target; time of gaze transfer away from the first target relative to heel contact in the target; percentage of time spent fixating the second target, and; visual previewing of future stepping constraints (number of fixations made towards the second target). The use of a non-parametric test was deemed necessary here as data were non-normally distributed. Separate Spearman's correlations were used to analyse data from the Threat condition and evaluate a possible relationship with the time of gaze transfer away from the first target and AP/ML stepping error.

2.2. Results

2.2.1. Self-reported measures

State anxiety. Participants reported significantly greater state fear of falling during Threat (*M* = 35.77%, *SD* = 29.22), compared to Baseline (*M* = 3.85%, *SD* = 6.50), *Z* = -3.06, *p* = 0.001, *r* = 0.89.

Attentional focus verbal reports. Under conditions of Threat, participants directed significantly greater attention towards both movement processes (*Z* = -2.11, *p* = 0.035, *r* = 0.59) and threats to balance (*Z* = -2.17, *p* = 0.030, *r* = 0.60). They also directed significantly less attention towards task-irrelevant information (*Z* = -2.07, *p* = 0.038, *r* = 0.57). According to this measure, there was no change in the amount of attention directed towards either worries or disturbing thoughts (*Z* = -1.63, *p* = 0.10, *r* = 0.45), or self-regulatory strategies (*Z* = -1.34, *p* = 0.18, *r* = 0.37). These data are presented in Table 2.

Table 2

2.2.2. Motor performance

Compared to Baseline (*M* = 3.80s, *SD* = 0.61), participants took significantly longer to complete the walking task during Threat (*M* = 4.47s, *SD* = 0.93), *t*(12) = -2.97, *p* = 0.006, *d* = 0.85. There was no significant Baseline-Threat change in stepping error in either the AP (*Baseline M* = 29.10mm, *SD* = 14.96; *Threat M* = 28.97mm, *SD* = 15.69, *t*(12) = 0.48, *p* = 0.96, *d* = 0.01) or ML direction (*Baseline M* = 17.58mm, *SD* = 8.15; *Threat M* = 16.62mm, *SD* = 8.08, *t*(12) = 0.28, *p* = 0.79, *d* = 0.12).

2.2.3. Gaze behaviour

First fixation (timing and location). Onset times to initial fixations were significantly shorter during Threat (*M* = 687.27ms, *SD* = 232.71) compared to Baseline (*M* = 797.14ms, *SD* = 308.88), $t(12) = 1.87$, $p = 0.043$, $d = 0.40$. Participants' first fixations were located significantly closer to the start of the walkway during Threat (*M* = 1.67, *SD* = 0.46) compared to Baseline (*M* = 2.25, *SD* = 0.46), $t(12) = 4.05$, $p = 0.001$, $d = 1.25$.

Duration of fixation(s) on the first walkway area. Participants spent a significantly greater percentage of time fixating the walkway before the first target during Threat (*M* = 15.69%, *SD* = 16.24) compared to Baseline (*M* = 2.82%, *SD* = 5.46), $Z = -2.50$, $p = 0.013$, $r = 0.69$ (see Figure 2).

Duration of fixation(s) on the first target. There was no difference in the percentage of time that participants spent fixating the first target between Baseline (*M* = 61.17%, *SD* = 17.58) and Threat (*M* = 58.44, *SD* = 20.75), $Z = -0.80$, $p = 0.42$, $r = 0.22$ (see Figure 2).

Duration of fixation(s) on the second walkway area. There was no difference in the percentage of time that participants spent fixating the second walkway area (located between the first and second target), between Baseline (*M* = 18.55%, *SD* = 12.47) and Threat (*M* = 21.86%, *SD* = 18.88), $t(12) = -0.57$, $p = 0.58$, $d = 0.21$ (see Figure 2).

Duration of fixation(s) on the second target. Participants spent a significantly lower percentage of time fixating the second target during Threat (*M* = 4.01%, *SD* = 7.27) compared to Baseline (*M* = 17.46%, *SD* = 17.97), $Z = -2.59$, $p = 0.01$, $r = 0.72$ (see Figure 2).

Figure 2

Visual previewing of future stepping constraints. Participants made significantly fewer fixations towards the second target during Threat (*M* = 0.20, *SD* = 0.29) compared to Baseline (*M* = 0.69, *SD* = 0.46), $Z = -2.99$, $p = 0.02$, $r = 0.80$. As Figure 3 illustrates, eight participants failed to make a single fixation towards the second target during the approach to the first target during Threat.

Figure 3

Number of gaze transfers between areas of interest. Participants made significantly fewer transfers of gaze between areas of interest during Threat (M = 0.51 transfers/second, SD = 0.25), compared to Baseline (M = 0.97 transfers/second, SD = 0.41), $t(12) = 6.02$, $p <$ 0.001, d = 1.38 (see Figure 4a).

Early transfer of gaze from the first target. Participants transferred their gaze away from the first stepping target significantly earlier during Threat (M = 349.50ms prior to heel contact, SD = 325.84) compared to Baseline (M = 167.34ms prior to heel contact, SD = 280.99), Z = -2.06, p = 0.019, r = 0.57. These data are presented in Figure 4b. During Threat, early gaze transfer was not significantly correlated with stepping error in either the AP (r = 0.55, p = 0.43) or ML (r = -0.55, p = 0.43) direction.

Figure 4

2.3. Discussion

The results from Experiment 1 demonstrate marked differences in how individuals visually scan their walking path during Threat. Here, participants made more rapid initial fixations towards more proximal areas of the walkway; indicating hypervigilance towards immediate stepping constraints/threats to balance. Participants also displayed significant reductions in visual exploration (reductions in the number of gaze transfers between different areas of the walkway). As predicted, these altered patterns of visual search were accompanied by participants reporting significantly greater attention directed towards external threat-related stimuli (such as the raised edges of the stepping target). There was, however, a lack of significant anxiety-related change in attention directed towards worries or disturbing thoughts, indicating that young adults anxious about falling will preferentially allocate attention towards external, rather than internal, threat-related stimuli.

While participants did preview the second target less during Threat (with 8 participants failing to fixate this constraint at all during the approach to the first target), this was not a consequence of increased time spent fixating the first target, as predicted. Rather, participants spent significantly longer fixating the walkway prior to this first target. We had predicted that participants would display a visual bias for the first target; given that this represented the immediate stepping constraint/threat to balance. However, it is possible that participants walking at height perceived the walkway before the first target (and the walkway in general) to be a threatening stimulus—as any misplaced steps on the walkway may have resulted in a fall. This interpretation is in line with the predictions presented in ACT/ACTS [Eysenck et al., 2007; Eysenck & Wilson, 2016], suggesting that anxiety increases the influence of the stimulus-driven system (i.e., immediate threats) at the expense of the goal-directed system (i.e., scanning one's whole environment and planning future stepping actions).

It is, however, of note that only one verbal report directly referred to perceiving the walkway before the first target as a threat to balance; with these threat-relevant statements instead more commonly referring to the targets themselves (e.g., "[I was directing attention towards…] The edges of the foam targets"). In contrast, a large quantity of statements referred to consciously controlling/monitoring each individual step (e.g., "Focusing on making sure my feet were always in the middle of the wooden plank" and "Attention was on keeping steps to the same length each time"). As such, we suggest that the increased time spent fixating the walkway before the first target represents a prioritisation of on-line visual information needed to consciously control/monitor each individual step—at the expense of planning future stepping actions. This interpretation is supported by research indicating that walkers rely on on-line control of gait to a greater extent when anxious about falling (Brown, Doan, McKenzie, & Cooper, 2006).

Taken together, these results suggest that when anxious about falling, participants displayed an initial hypervigilance towards immediate threats to balance. Motivated to avoid falling, they subsequently attempted to consciously control/monitor each individual step—resulting in the utilisation of on-line vision to control locomotion (i.e., ‘freezing’ gaze to the ground one step ahead, at the expense of transferring gaze between the first and second targets, three-to-five steps ahead). As such, at the time when stepping into the first target, there would have been an urgent need to acquire visual information regarding subsequent constraints. It seems intuitive that this is why participants transferred their gaze from the first target significantly earlier (prior to heel contact) during Threat trials (see Figure 4b). However, it is also possible that this behaviour is a further reflection of the increased influence of the stimulus-driven system (at the expense of goal-directed attention, as predicted by ACT/ACTS [Eysenck et al., 2007; Eysenck & Wilson, 2016]), with participants directing preferential attention towards upcoming constraints at the expense of fixating the first target until the precision step has been completed (i.e., the current goal).

Our interpretations of observed behaviours propose an interplay between distraction and self-focus/explicit monitoring factors—thus providing support for integrated perspectives, specifically ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016). However, as these interpretations are drawn largely from self-reported data, we are unable to draw any conclusions regarding causality between these factors. For example, it is possible that the increased self-focus/explicit monitoring reported is unrelated to any alterations in visual search behaviours; with these changes occurring simultaneously, yet unrelated, to one another. As such, there is a need to conduct further theoretically-driven experimental manipulations to evaluate possible causal relationships underpinning altered gaze behaviour during adaptive gait.

3. Experiment 2

Experiment 1 implicates possible psychological factors that may contribute to anxiety-related changes in visual search. However, given the aforementioned difficulties in interpreting data pertaining to gaze behaviour, it is necessary to experimentally test these interpretations, through the isolation of independent factors implicated during Experiment 1. For example, while we interpret the increased time spent fixating the immediate walkway areas to indicate increased reliance on on-line vision to consciously control discrete stepping movements, it is possible that this behaviour may instead reflects a gaze bias for external threats, and subsequent inability to shift attention back towards planning future stepping actions. Similarly, while we interpret the premature gaze transfers observed during Threat to be a consequence of the reduced time spent fixating subsequent stepping targets by virtue of participants instead prioritising on-line vision to consciously control individual steps, it is possible that this behaviour may be unrelated to conscious movement processing and alternatively reflect an anxiety-related increased dominance of the stimulus-driven attentional system—as noted previously (and predicted by ACT/ACTS [Eysenck et al., 2007; Eysenck & Wilson, 2016]). Therefore, Experiment 2 sought to determine whether similar patterns of visual search described in Experiment 1 during anxiety can be induced during an experimentally induced internal focus of attention, independent of fall-related anxiety.

As with the Threat condition in Experiment 1, we predicted to similarly observe a visual prioritisation of the walkway areas needed for on-line control of individual steps (i.e., participants 'freezing' their gaze to the ground one step ahead, at the expense of previewing the second target, approximately three-to-four steps ahead) during Internal focus of attention. Consequently, as participants will have obtained limited information regarding the second target at the time they step towards the first target, we expect to observe similar early transfers of gaze away from the first target (i.e., prior to heel contact). However, as we interpret the rapid initial fixations towards more immediate areas of the walkway during Experiment 1 to indicate a hypervigilant gaze bias for immediate threats, we did not expect to observe comparable behaviours during either condition in Experiment 2.

A second aim of Experiment 2 was to explore the possible mechanisms through which adopting an internal focus of attention may alter visual search during locomotion. For example, consciously attending to movement during locomotion has been shown to reduce processing efficiency, thus limiting the resources available for processing concurrent tasks (Ellmers & Young, 2018; Young et al., 2016)—which may include extracting relevant visual information from one's walking environment (Uiga et al., 2015b). Indeed, researchers (e.g., Young & Williams, 2015) have proposed reduced cognitive resources as one possible explanation for restricted visual previewing and subsequent premature transfers of gaze. Therefore, it is possible that consciously controlling/monitoring locomotion may influence changes in visual search by virtue of reduced processing efficiency, potentially due to an inability to retain previewed environmental information about distal path constraints (Young & Williams, 2015). As such, while we attribute the majority of changes observed in Experiment 1 to altered (on-line visual) prioritisation resulting from attempts to consciously process movement—rather than associated reductions in processing resources—we regardless deemed it necessary to also consider (and discount) the influence of reduced attentional resources available for movement planning on visual search during gait. Given that an internal focus of attention during locomotion is associated with verbal processes (Young et al., 2016), this was achieved through the manipulation of a verbal dual-task. However, we predicted to observe significantly different visual behaviours during this condition compared to Internal focus of attention (and a lack of any behaviours comparable to Threat in Experiment 1). Specifically, we predicted to observe a general 'disengagement' from proactive visual search during Dual-task (Ellmers et al., 2016), which we hypothesise will manifest itself as reduced time spent fixating the walkway in general (particularly the stepping constraints), and increased time spent fixating areas outside the walking path.

3.1. Methods

3.1.1. Participants

The same 14 participants from Experiment 1 participated in Experiment 2. As we wished to explore the potential factors underpinning the specific anxiety-related changes observed in Experiment 1, we deemed it most appropriate to utilise the same sample previously studied, rather than recruiting a new sample who may differ on trait variables likely to influence visual search during gait (such as an individual's trait propensity to consciously process their movements; Ellmers et al., 2016). To ensure an absence of a practice effect occurring during the testing session, separate paired-samples t-tests/Wilcoxin tests (dependent on whether the data were normally distributed) were used to compare Baseline variables between the two experiments. Aside from a significant difference between the duration of fixation(s) on the first target ($Z = -1.99$, $p = 0.046$, $r = 0.55$), there were no other significant differences observed between experiments for any other Baseline variables (all p's > 0.28). However, as the overall mean duration of fixations on the first target for Experiment 1 ($M = 61.17\%$, $SD = 4.88$) and Experiment 2 ($M = 55.96\%$, $SD = 5.87$) differed by only 5.21%, and all other variables were statistically comparable between experiments, we reason that this indicates an absence of a true practice effect between Experiment 1 and 2.

3.1.2. Procedure

Experiment 2 utilised an identical experimental task as Experiment 1. Following the completion of Experiment 1, participants received a 15-minute break. Once the calibration of the eye-tracking system was re-verified for accuracy, participants walked again at a comfortable, self-determined pace across the same walkway used in Experiment 1 and stepped into the same two foam targets. Participants completed one five-trial block of walks under each of the three randomised conditions: (1) Baseline; (2) Internal focus of attention, and; (3) Cognitive dual-task. All three conditions involved participants completing the protocol at ground level.

Baseline. As with Experiment 1, Baseline involved participants completing the protocol with no other instructions other than to “step into the middle of the target with the middle of your foot”.

Internal focus of attention. During this condition, participants were informed that they needed to consciously process their movements throughout the trial, as after each trial in this condition, they would be asked a question relating to their movement. These questions were similar to those used previously to determine ‘internal awareness’ of movements (Uiga et al., 2015a; Young et al., 2015), and were designed to encourage the adoption of an internal attentional focus throughout the duration of the trial. Examples included: “How many steps did you take during the trial?” and “Which of your feet did you step between the two targets with?” The questions asked were the same for all participants. 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, participants’ response accuracy was recorded as an additional manipulation check. Two participants provided an incorrect answer for one trial, respectively. Participants completed a practice-trial prior to the start of the experimental block, to familiarise themselves with the style of movement questions they would be required to answer. This experimental manipulation has been validated by Ellmers and Young (2018) as a method to successfully induce levels of conscious movement processing during adaptive gait comparable to those observed under conditions of fall-related anxiety.

Cognitive dual-task. This condition consisted of performing the protocol while concurrently subtracting out loud in 7s from a randomised number between 70 and 90 (Brustio, Magistro, Zecca, Rabaglietti, & Liubicich, 2017; Srygley, Mirelman, Herman, Giladi, & Hausdorff, 2009). Participants were presented with this randomised number directly prior to the onset of the ‘go’ tone, to ensure that they had not already begun subtracting prior to the start of each trial. Once they heard the ‘go’ tone, participants began to walk and subtract out loud. Participants’ first verbalised response was the subtracted target value of the randomised number (i.e., first verbalisation of 83 if the randomised number presented was 90). Participants were instructed to allocate an equal amount of attention towards both the walking and arithmetic task (Ellmers et al., 2016; Hall, Echt, Wolf, & Rogers, 2011; Taylor, Delbaere, Mikolaizak, Lord, & Close, 2013). As previous research documents cognitive dual-task costs of between 10-50% (i.e., participants verbalise 10-50% fewer correct calculations when performing the cognitive task while walking, compared to during single-task while seated) for a comparable motor/cognitive task (Ellmers et al., 2016), any trials in which dual-task cognitive performance declined by over 50% (compared to when seated) were excluded from analysis. This ensured that trials would only be analysed if participants were allocating adequate attention towards the cognitive task. However, as cognitive dual-task costs were below 50% for all participants (M = 30.23%, SD = 18.13), no trials were excluded from analysis on this basis.

3.1.3. Measures

The motor performance variables collected in Experiment 2 were identical to those investigated previously in Experiment 1. These were defined and calculated using an identical method as described in Experiment 1. Identical gaze behaviour variables were also calculated, with the exception of an additional fifth walkway area: ‘outside areas’ (any area of the surrounding environment that was not along the walking path). Based on previous research (Ellmers et al., 2016), this additional area was added to assess the degree to which participants ‘disengaged’ from visual search during Cognitive dual-task. As with Experiment 1, trials in which the point of gaze crosshair disappeared for the duration of three frames or more were discarded. However, as all 14 participants had at least three usable trials for each condition, no participants were excluded from analyses. A total of 57 trials were analysed for Baseline (M = 4.07 trials per participant), 61 trials analysed for Cognitive dual-task (M = 4.36 trials per participant) and 56 trials analysed for Internal focus of attention (M = 4.00 trials per participant). As with Experiment 1, kinematic data were assigned a randomised code, to allow for blinded analysis were assigned a randomised code, to allow for blinded analysis. As there were no between-condition differences in the environmental scene present in the eye-tracking videos (unlike Experiment 1), gaze data analysis was also blinded.

3.1.4. Statistical analysis

Motor performance. Separate repeated-measures ANOVAs (effect size reported as partial eta squared; Bonferonni post-hoc tests used to follow up any statistically significant results) were used to explore the effect of experimental condition on: Time to complete the walking trial and stepping error in both the AP and ML planes for the first target.

Gaze behaviour. Separate Friedman tests were used to determine the effect of Condition on: the time of the first fixation; the location of the first fixation; percentage of time spent fixating the first walkway area; percentage of time spent fixating the first target; time of gaze transfer away from the first target relative to heel contact; visual previewing of future stepping constraints; percentage of time spent fixating the second target, and; percentage of time fixating outside areas. The use of a non-parametric test was deemed necessary as data were non-normally distributed. Any significant effects were followed up by separate Wilcoxin tests comparing each of the three conditions: Baseline, Internal focus of attention and Cognitive dual-task (Bonferonni corrected to 0.017). Due to the difficulties associated with calculating effect size for Friedman tests, effect sizes are calculated (and reported as $r=Z/\sqrt{N}$) instead for any Wilcoxin test follow-ups (as recommended by Field, 2009). Separate repeated-measures ANOVAs (effect size reported as partial eta squared; Bonferonni post-hoc tests used to follow up any statistically significant results) were used to determine the effect of Condition on: the number of gaze transfers between the areas of interest, and; the duration (presented as a percentage) spent fixating the second walkway area. Two participants were excluded from the early gaze transfer analysis, as one participant did not fixate the first target in any trials during two of the three conditions; while the second participant only fixated the first target in one out of five trials for two of these conditions, with the time that they transferred their gaze away from the first target during these two trials falling >2.5-3 SD above the overall group mean. Therefore, it was not possible to reliably determine the difference between when these participants looked away from, and stepped into, the first target.

3.2. Results

3.2.1. Motor performance

There was a significant effect of Condition on the time taken to complete the walking trial ($F(2,26) = 11.84$, $p < 0.001$, $\eta p^2 = 0.48$). Compared to Baseline ($M = 3.74$s, $SD = 0.59$), participants took significantly longer to complete the walking task during both Cognitive dual-task ($M = 4.39$s, $SD = 0.72$, $p < 0.001$) and Internal focus of attention ($M = 4.15$s, $SD = 0.85$, $p = 0.022$). There was a lack of significant difference in times to complete the walking task observed between Cognitive dual-task and Internal focus of attention ($p = 0.48$). There was no significant effect of Condition on stepping error in either the AP ($F(2,26) = 1.81$, $p = 0.18$, $\eta p^2 = 0.12$) or ML direction ($F(2,26) = 0.61$, $p = 0.55$, $\eta p^2 = 0.05$).

3.2.2. Gaze behaviour

First fixation (timing and location). There was a significant effect of Condition on the time to the first fixation ($\chi^2(2) = 9.33$, $p = 0.009$). Post-hoc tests revealed that compared to Baseline ($M = 817.86$ms, $SD = 313.56$), onset times to initial fixations were significantly longer during both Cognitive dual-task ($M = 982.54$ms, $SD = 391.60$, $p = 0.013$, $r = 0.60$) and Internal focus of attention ($M = 907.46$, $SD = 286.80$, $p = 0.009$, $r = 0.64$). There was a lack of significant difference observed between Cognitive dual-task and Internal focus of attention ($p = 0.41$, $r = 0.06$).

There was also a significant effect of Condition on the location of the first fixation ($\chi^2(2) = 10.47$, $p = 0.005$). Post-hoc tests revealed that participants' first fixations occurred significantly nearer the start of the walkway during Internal focus of attention ($M = 1.66$, $SD = 0.67$), compared to Baseline ($M = 2.10$, $SD = 0.69$, $p = 0.002$, $r = 0.76$). There was a lack of significant difference observed between Cognitive dual-task ($M = 1.89$, $SD = 0.56$) and either Baseline ($p = 0.058$, $r = 0.51$) or Internal focus of attention ($p = 0.17$, $r = 0.36$).

Duration of fixation(s) on the first walkway area. There was a significant effect of Condition on the duration spent fixating the first walkway area, during the approach to the first target ($\chi^2(2) = 12.72$, $p = 0.002$). Post-hoc tests revealed that participants spent a significantly greater percentage of time fixating the walkway before the first target during Internal focus of attention ($M = 17.94\%$, $SD = 18.50$), compared to Baseline ($M = 6.50\%$, $SD = 14.39$, $p = 0.003$, $r = 0.71$). There was also a trend towards significance, for a greater percentage of time spent fixating this walkway area during Internal focus of attention, compared to Cognitive dual-task ($M = 9.04\%$, $SD = 12.21$, $p = 0.024$, $r = 0.53$). There was a lack of significant difference observed between Baseline and Cognitive dual-task (p = 0.16, r = 0.27) (see Figure 5).

Duration of fixation(s) on the first target. There was a significant effect of Condition on the duration spent fixating the first walkway area, during the approach to the first target ($\chi^2(2)$ = 7.54, p = 0.023). Post-hoc tests revealed that participants spent significantly less time fixating the first target during Cognitive dual-task (M = 36.69%, SD = 22.68), compared to both Baseline (M = 54.43%, SD = 21.15, p = 0.008, r = 0.64) and Internal focus of attention (M = 54.21%, SD = 19.76, p = 0.017, r = 0.57). There was a lack of significant difference observed between Baseline and Internal focus of attention (p = 0.41, r = 0.07) (see Figure 5).

Duration of fixation(s) on the second walkway area. There was a significant effect of Condition on the duration spent fixating the second walkway area during the approach to the first target ($F(1.28,16.58)$ = 6.17, p = 0.018, ηp^2 = 0.32). While post-hoc tests revealed a trend for greater times spent fixating the walkway between the first and second target during Cognitive dual-task (M = 34.14%, SD = 21.69), compared to both Baseline (M = 20.58%, SD = 13.12, p = 0.084) and Internal focus of attention (M = 18.13%, SD = 11.17, p = 0.058), these did not reach significance. There was also a lack of significant difference observed between Baseline and Internal focus of attention (p = 1.00) (see Figure 5).

Duration of fixation(s) on the second target. There was a significant effect of Condition on the duration spent fixating the second target, during the approach to the first target ($\chi^2(2)$ = 13.88, p = 0.001). Post-hoc tests revealed that participants spent significantly less time fixating the second target during both Cognitive dual-task (M = 8.27%, SD = 13.93, p = 0.004, r = 0.72) and Internal focus of attention (M = 8.90%, SD = 21.44, p = 0.005, r = 0.69), compared to Baseline (M = 18.49%, SD = 22.11). There was a lack of significant difference observed between Cognitive dual-task and Internal focus of attention (p = 0.29, r = 0.15) (see Figure 5).

***Duration of fixation(s) on outside areas*.** There was a significant effect of Condition on the duration spent fixating the second target, during the approach to the first target ($\chi^2(2)$ = 8.82, *p* = 0.012). Post-hoc tests revealed that participants spent significantly more time fixating areas outside the walkway during Cognitive dual-task (*M* = 11.95%, *SD* = 21.79), compared to Baseline (*M* = 0.00%, *SD* = 0.00, *p* = 0.014, *r* = 0.59), with a further trend when Cognitive dual-task was also compared to Internal focus of attention (*M* = 0.82%, *SD* = 2.53, *p* = 0.032, *r* = 0.50). There was a lack of significant difference observed between Baseline and Internal focus of attention (*p* = 0.09, *r* = 0.36) (see Figure 5).

Figure 5

Visual previewing of future stepping constraints. There was a significant effect of Condition on the numbers of fixations made towards the second target, during the approach to the first target ($\chi^2(2)$ = 12.63, *p* = 0.002). Post-hoc tests revealed that compared to Baseline (*M* = 0.72, *SD* = 0.46), participants made significantly fewer fixations towards the second target during both Internal focus of attention (*M* = 0.17, *SD* = 0.28, *p* = 0.02, *r* = 0.76) and Cognitive dual-task (*M* = 0.39, *SD* = 0.33, *p* = 0.015, *r* = 0.58). Participants also made significantly fewer fixations towards the second target during Internal focus of attention, compared to Cognitive dual-task (*p* = 0.04, *r* = 0.72). During Internal focus of attention, eight participants failed to make a single fixation towards the second target during the approach to the first target—compared to two and three participants during Baseline and Cognitive dual-task, respectively.

Number of gaze transfers between areas of interest. There was no significant effect of Condition on the number of transfers of gaze between areas of interest ($F(2,26)$ = 0.90, *p* = 0.42, ηp^2 = 0.07).

Early transfer of gaze from the first target. There was a significant effect of Condition on the time of early gaze transfer away from the first target ($\chi^2(2)$ = 8.00, *p* = 0.018). Post-hoc tests revealed that participants transferred their gaze away from the first stepping target significantly earlier during Cognitive dual-task (*M* = 546.98ms prior to heel contact, *SD* = 330.32), compared to both Baseline (*M* = 190.98ms prior to heel contact, *SD* = 199.40, *p* = 0.014, *r* = 0.63) and Internal focus of attention (*M* = 199.77ms prior to heel contact, *SD* = 108.12, *p* = 0.002, *r* = 0.84). There was a lack of significant difference observed between Baseline and Internal focus of attention (*p* = 0.44, *r* = 0.05) (see Figure 6). During Cognitive dual-task, early gaze transfer was not significantly correlated with stepping error in either the AP (*r* = -0.15, *p* = 0.32) or ML (*r* = 0.31, *p* = 0.17) direction.

Figure 6

3.3. Discussion

As predicted, during Internal focus of attention, participants' initial fixations were made towards more proximal areas of the walkway nearest their feet. They also spent more time fixating the first walkway area (before the first target) and less time visually previewing the second target (see Figure 5), with fewer fixations also made towards the second target. As with the results presented in Experiment 1 during Threat, these findings also seem indicative of participants prioritising the areas of the walkway needed for on-line control of stepping movements—at the expense of planning future stepping actions. These findings implicate conscious movement processing as one factor underpinning certain anxiety-related changes in visual search. However, despite acquiring limited visual information about the subsequent stepping constraints during Internal focus of attention, participants did not demonstrate significantly earlier transfers of gaze away from the first target (see Figure 6). This was contrary to our predictions and suggests that early transfers of gaze previously observed in anxious young adults in Experiment 1—and high-risk older adults (Young & Hollands, 2012b; Young et al., 2012)—are not necessarily a direct consequence of the limited acquisition of spatial information about upcoming constraints as a result of restricted visual previewing; as previously assumed (Young & Williams, 2015). Rather, previously observed premature transfers of gaze away from the first target appear to reflect a gaze bias for upcoming threats—thus supporting the predictions presented in ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016), whereby anxiety is predicted to result in an increased influence of the stimulus-driven system (at the expense of goal-directed attention, e.g., fixating the first target until the precision step has been completed).

Interestingly, participants did transfer gaze away from the first target significantly earlier during Cognitive dual-task (compared to both Baseline and Internal focus of attention; see Figure 6), in addition to reducing the number of fixations made towards the second target. Dual-tasking participants also fixated both stepping constraints (first and second target) for significantly shorter durations, instead fixating areas outside the walking path for longer durations—transferring their gaze away from the first target prematurely, to do so. These findings suggest that visually previewing stepping constraints in a feedforward manner requires attentional resources. As such, unlike the reduced time spent fixating (subsequent) stepping constraints during Internal focus of attention, we suggest that behaviours observed during Cognitive dual-task represent a 'disengagement' from performing optimal visual planning, in order to 'liberate' cognitive resources needed to complete the secondary task (Ellmers et al., 2016). Consequently, while the outcome (reduced previewing of subsequent constraints) is similar between these two conditions, we argue for differences in the causal mechanisms. While we interpret the reduced previewing observed during Dual-task to be indicative of a general disengagement, we view these behaviours during Internal focus of attention to instead represent changes in prioritisation (with participants visually prioritising the areas necessary for on-line movement control, much like during Threat in Experiment 1).

These findings suggest that previously described visual search behaviours observed in high-risk anxious older adults (i.e., early transfers of gaze [Chapman & Hollands, 2010; Young et al., 2012]) may be the consequence of fall-related anxiety (and subsequent attempts to consciously control/monitor movement), age-related decline in cognitive resources, or a combination of both. However, while research indicates that consciously processing movement *can* reduce attentional resources available for processing concurrent tasks (Ellmers & Young, 2018; Gage et al., 2003; Uiga et al., 2015b; Young et al., 2016), the lack of comparable visual search strategies observed between Cognitive dual-task and Threat in Experiment 1 suggest that anxiety-related alterations in visual search are unlikely to simply reflect reduced attentional resources available for processing this information.

Furthermore, previous attempts to interpret anxiety-related changes in visually-guided gait have assumed that behaviours observed are all interlinked (e.g., reduced visual previewing and early transfers of gaze [Young & Williams, 2015]). However, the results presented in Experiment 2 suggest that these different behaviours can operate with relative independence and can be mediated by different attentional factors.

4. General Discussion

The present experiments evaluated the existence of a causal link between fall-related anxiety and altered patterns of visual search and explored possible mechanisms underpinning these changes. As illustrated in Figures 2 and 3, participants demonstrated reduced visual previewing during Threat in Experiment 1, prioritising the immediate areas of the walkway (the first walkway area) at the expense of subsequent stepping constraints (the second target). In addition, they transferred their gaze between the different areas of the walkway significantly less during Threat, indicating reduced visual exploration (see Figure 4a). Participants made earlier initial fixations (reductions in the time between the start of the trial and the onset of their initial fixation) towards more proximal areas of the walkway (areas of the walkway closer to the ‘start’ line) and transferred their gaze away from the first target significantly earlier (i.e., before they had stepped into the target; see Figure 4b). Based on both the verbal report data presented in Experiment 1, and the altered visual search observed during the experimental manipulations conducted in Experiment 2, we suggest these results implicate an interplay between both distraction and self-focus/explicit monitoring processes as underpinning the anxiety-related changes in visual search reported in Experiment 1. As such, these findings provide strong support for integrated perspectives—specifically ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016).

4.1. Visual control of locomotion when anxious

Results from Baseline in our present research indicate that when presented with a series of stepping constraints, walkers will utilise visual information regarding upcoming constraints in a feedforward manner (Matthis et al., 2017). For example, during Baseline participants spent approximately 20% of the approach to the first target fixating the subsequent target (typically representing a distance of three-to-five step lengths distance). In contrast, during Threat, participants spent significantly less time previewing the second target and instead spent significantly more time fixating the walkway prior to the first target. As the first walkway area would have represented a distance of typically one step length away, we view these anxiety-related changes in visual search as indicating increased on-line visual control of stepping. This supports previous research indicating that older adults anxious about falling prioritise on-line vision to control stepping (Brown et al., 2006).

We propose that consciously prioritising on-line visual information needed to control discrete stepping movements disrupts the automatic visuomotor visual processes that typically underpin goal-directed locomotor movements (Hollands, Hollands, & Rietdyk, 2017). Seminal research presented by Wulf and Prinz (2001) describes how consciously attending to on-line movement control during a dynamic balance task can interfere with the automatic processes through which balance is typically controlled. We suggest that fall-related anxiety may influence visual search behaviour via similar mechanisms; with conscious on-line processing disrupting the automatic, sub-conscious co-ordination between gaze and stepping movements. Actively controlling each individual step through on-line vision, rather than relying on feedforward control to guide movement, will likely reduce both gait stability and, subsequently, safety during locomotion by limiting the individual's ability to perceive, identify and negotiate subsequent/future threats (Matthis & Fajen, 2014).

Contrary to our predictions, earlier transfer of gaze observed during Threat was not associated with increased stepping error. This was surprising, as previous research demonstrates a causal link between early gaze transfer and suboptimal stepping performance; albeit in older adults (Young & Hollands, 2010). It seems that young/healthy adults may be able to maintain accurate foot placements during precision stepping without visual feedback of their foot position—unlike either older adults (Chapman & Hollands, 2006a) or those with Parkinson's (Vitório, Gobbi, Lirani-Silva, Moraes, & Almeida, 2006). Therefore, we may expect healthy young adults to be less susceptible to increased stepping errors following a premature gaze transfer, as requirements to maintain gaze fixation on the target until foot contact are reduced.

4.2. Support for integrated theoretical perspectives

As with Threat (Experiment 1), participants reduced visual previewing during Internal focus of attention, once again prioritising proximal areas of the walkway at the expense of subsequent stepping constraints (Experiment 2). This finding provides evidence of a causal link between consciously processing ones movements and altered visual search, suggesting that conscious movement processing results in the prioritisation of on-line control mechanisms at the expense of planning future stepping actions. Based on this causal relationship—combined with anxious participants reporting the direction of greater attention towards consciously processing individual stepping movements during Experiment 1—we propose that the comparable reductions in visual previewing observed during Threat in Experiment 1 are due, at least in part, to anxiety-related increases in conscious movement processing. Specifically, we propose that this internal focus of attention manifested itself in the conscious prioritisation of the immediate visual information needed to control each discrete step, with this behaviour detracting from the capacity to perform the proactive, feedforward visual search observed during Baseline.

In Experiment 1, onset times to initial fixations were also significantly shorter during Threat, compared to Baseline. This indicates that, much like with other forms of anxiety (Staab, 2014), fall-related anxiety may induce a hypervigilant gaze response to threatening stimuli (i.e., a visual bias for threatening stimuli, resulting in rapid initial fixations towards potential threats to balance). This idea is further supported by research suggesting that older adults fearful of falling display an attentional bias towards threatening, fall-relevant stimuli (Brown, White, Doan, & de Bruin, 2011). In Experiment 2, however, onset times to initial fixations were significantly longer during both Internal focus of attention and Cognitive dual-task (compared to Baseline)—suggesting that this hypervigilance is not related to either of these factors. Instead, this supports predictions made in ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016), indicating increased sensitivity for the stimulus-driven attentional system.

Participants also transferred their gaze away from the first target significantly earlier during Threat, compared to Baseline, with no such changes observed during Internal focus of attention (see Figure 6). As we observed comparable reductions in visual previewing during both Threat and Internal focus of attention, participants would have obtained similarly limited visual information about the subsequent stepping constraints in both conditions. This suggests that premature transfer of gaze away from the first target is not the direct result of any failure to obtain information about subsequent stepping constraints; as suggested by Young and Williams (2015). Rather, we interpret this early transfer of gaze during Threat to be indicative of a gaze bias towards upcoming threats to balance; similar to the earlier fixations made towards the first walkway area at the start each trial—and unlike the early transfer of gaze observed during Cognitive dual-task, which we interpret as a 'disengagement' from proactive feedforward visual search. We argue that this finding provides further support for ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016), whereby anxiety is predicted to increase the influence of the stimulus-driven system (at the expense of goal-directed attention, e.g., fixating the first target until the precision step has been completed).

These interpretations clearly highlight an interplay between distraction and self-focus/monitoring factors, thus providing strong support for integrated accounts of anxiety-related disruptions in perceptual-motor performance. Specifically, we suggest that this putative interaction can be placed within the context of ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016)—which posits that anxiety "causes attention to be directed towards detecting the source of the threat and deciding how to respond" (Wilson, 2008, pp. 195). We propose that the initial hypervigilance (as well as premature transfers of gaze towards subsequent stepping constraints) observed during Threat may represent preferential attention allocated towards detecting the source of threat, with subsequent conscious on-line movement control selected as the behavioural response. It is also possible to place these results within the context of Nieuwenhuys and Oudejans' (2012) *integrated model of anxiety and perceptual-motor performance*, whereby anxiety is argued to influence the information towards which individuals attend (i.e., hypervigilance towards immediate threats), how this information is then interpreted (i.e., interpreting the raised edges of the targets as threatening, as indicated in the verbal report data from Experiment 1) and the subsequent selection and execution of the motor response (i.e., conscious on-line control of individual steps). Our results illustrate a complex picture of multiple, potentially interacting attentional factors which may contribute to the altered gaze behaviour observed when anxious about falling. As such, the results highlight the importance of considering the interplay between a multitude of psychological factors when attempting to conceptualise the impact of fall-related anxiety on locomotion—rather than focusing exclusively on either distraction or self-focus influences.

Participants also transferred their gaze between different areas of the walking environment less during Threat, compared to Baseline. This finding is in line with previous research describing reduced visual exploration in anxious older adults (Young et al., 2012) and individuals suffering from anxiety-related disorders at height (Kugler et al., 2013; 2014). However, no such changes were observed during either Internal focus of attention or Cognitive dual-task in Experiment 2. Consequently, we suggest that this ‘freezing of gaze’ likely reflects an anxiety-related prioritisation of visual stability, in an attempt to reduce potentially destabilising head, and eye-in-head, movements (Staab, Balaban, & Furman, 2013; Young & Williams, 2015). Indeed, Young and Williams (2015) suggest that anxiety-related reductions in visual exploration may “represent attempts to minimize ‘unnecessary’ destabilizing movements even when, in the instance of visual search, they are required for picking up external information and movement planning during adaptive gait” (p. 9). Alternatively, it is possible that reduced visual exploration may reflect anxiety-related inefficiencies within the ‘shifting’ function of the central executive (i.e., optimally allocating attention within and between tasks)—as proposed by ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016). For example, Eysenck and Wilson (2016) suggest that anxiety may lead to “[…] inefficient shifting between cues” (p. 340) which during locomotion may include different areas of the walking path. This interpretation would suggest that anxiety may impair a walker’s ability to shift attention between the immediate areas of the walkway needed for on-line control and the distal areas required for effective feedforward planning.

4.3. Future directions

In the current study we manipulated and evaluated behaviours in healthy young adults, in an attempt to establish causal links between fall-related anxiety and behaviours previously observed in clinical populations that also present countless potential confounding factors (e.g., age-related decline in visuomotor processing). Consequently, it is possible that behaviours observed in the present research, in addition to subsequent interpretations, may not generalise to older adults and other clinical populations. Furthermore, it is possible that high-risk older adults may allocate attention differently to young adults when anxious about falling. For example, Tinetti and Powell (1993) characterise fear of falling as a lasting concern about falling. It is, therefore, possible that older adult fallers may prioritise attending to worrisome thoughts related to these concerns when their balance is threatened; potentially resulting in different patterns of anxiety-related attentional processing and subsequent alterations in visuomotor behaviour. As such, internal, task-irrelevant distracters—such as ruminative worries/concerns about falling—may be of more relevance for high-risk older adults and clinical populations.

5. Conclusion

Our results demonstrate a causal link between fall-related anxiety and previously described patterns of visual search observed in both high-risk, anxious older adults (Young et al., 2012; Young & Hollands, 2012b) and individuals suffering from clinical anxiety disorders (Kugler et al., 2013; 2014); specifically relating to reduced visual previewing and an early transfer of gaze away from stepping targets to view upcoming constraints. Based on the gaze behaviour data from Experiments 1 and 2, and the verbal report data from Experiment 1, we propose an interplay between distraction and self-focus/explicit monitoring processes. Specifically, we suggest that when anxious, participants displayed increased initial hypervigilance towards immediate threats to balance, reducing their visual exploration in an attempt to limit potentially destabilising movements. Motivated to avoid falling, participants subsequently attempted to consciously control their walking. We propose that this internal focus of attention manifested itself as a greater reliance on on-line vision to consciously control each individual step (with this behaviour detracting from the capacity to perform the proactive, feedforward visual search observed during Baseline). This mode of visual control persisted until they perceived that the immediate threat (first stepping target) had been negotiated (i.e., once they had stepped towards it), whereby they directed their gaze prematurely towards the next immediate threat to their balance. We suggest that these findings provide strong support for integrated accounts of anxiety-related disruptions in perceptual-motor performance—specifically ACT/ACTS (Eysenck et al., 2007; Eysenck & Wilson, 2016).

The current findings demonstrate that both fall-related anxiety and an internal focus of attention can disrupt the maintenance of proactive, feedforward visual search during adaptive gait, supporting previous claims that altered visual search observed in high-risk older adults may be a consequence of anxiety-related changes within attentional processing (Young & Williams, 2015). Identifying factors that underpin anxiety-related disruption of effective gaze behaviour during locomotion is an essential step in developing future rehabilitation strategies. Consequently, aside from the theoretical implications of this work, the current findings will contribute to the development of empirically grounded falls-prevention tools aimed at reducing reliance on explicit conscious movement control (Kal, Van Der Kamp, & Houdijk, 2013; Lam, Maxwell, & Masters, 2009; Zhu, Poolton, Wilson, Masters, & Maxwell, 2011).

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Attentional categories	**Examples**
Movement processes	Participant 1: *"I tried to keep all movement as controlled as possible."* Participant 10: *"Attention was on keeping steps to the same length each time."*
Threats to balance	Participant 6: *"I directed my attention towards the edges of the walkway."* Participant 10: *"[I directed my attention towards] The edges of the foam target."*
Worries or disturbing thoughts	Participant 4: *"I was worried about falling down."* Participant 11: *"I felt worried I might lose my balance and fall."*
Self-regulatory strategies	Participant 3: *"Thinking of the platform and reminding myself that [walking on the raised platform during Threat] was the same as walking at ground level."* Participant 12: *"Thinking about getting to the end so I could come down to ground height."*
Task-irrelevant information	Participant 12: *"My mind was wandering about other things [aside from the walking task]."* Participant 13: *"I thought that I was feeling a little bit thirsty."*

Table 1. Example items for each attentional category.

Attentional category	Baseline	Threat
Movement processes	22	33*
Threats to balance	7	15*
Worries or disturbing thoughts	0	5
Self-regulatory strategies	0	3
Task-irrelevant information	8	0*
Total	37	56

Table 2. Number of statements in each attentional category obtained from the verbal reports for both Baseline and Threat, *$p < 0.05$

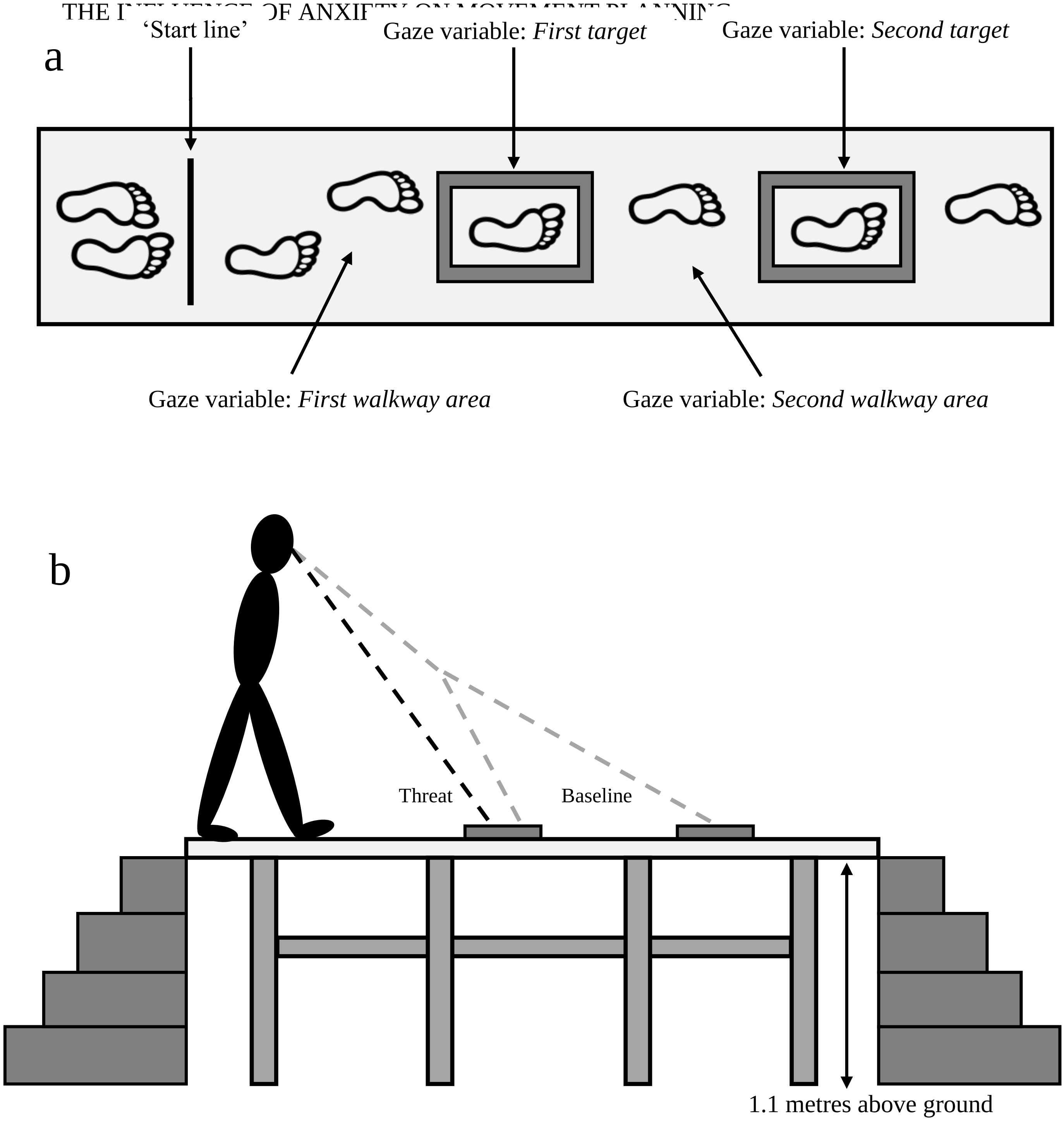

Figure 1a. Schematic diagram of the walkway and precision stepping task. The foam targets had a border width and height of 4cm (i.e., the foam border was 4cm wide and raised 4cm from the walkway). The inside area of the target was 19cm x 41.5cm (width and length, respectively). The arrows denote the different areas of interest for which the walkway was separated into for the gaze analysis.

Figure 1b. Schematic diagram of the raised walkway during Threat. The black dashed lines represent the 'restricted' visual exploration predicted during Threat, whereby participants prioritise the immediate stepping constraint at the expense of previewing future stepping actions, while the grey dashed lines represent the 'proactive' visual search predicted during Baseline at ground level.

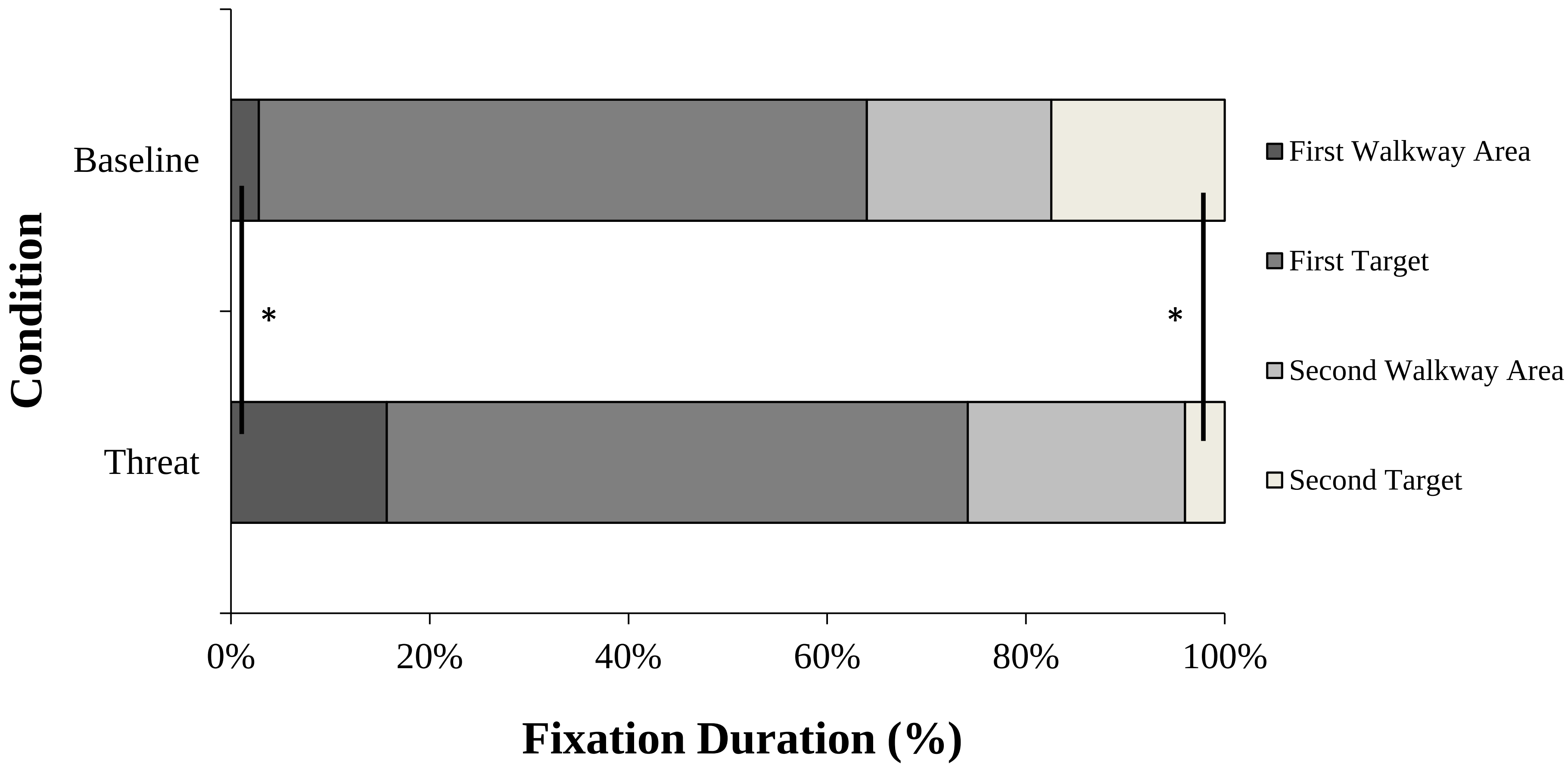

Figure 2. Duration (mean duration as a percentage) of fixations the different areas of the walkway under conditions of Baseline and Threat, *p<0.05.

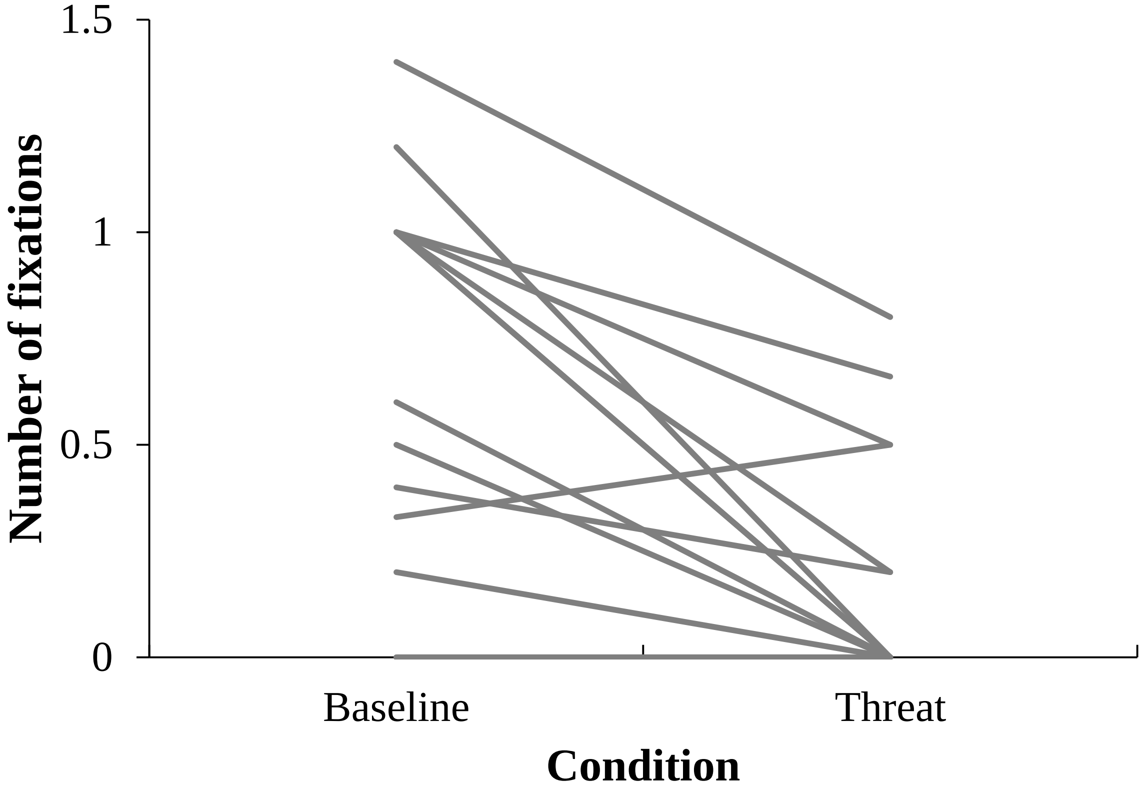

Figure 3. Number of fixations made towards the second during, during the approach to the first target. Note, that two separate participants fixated the second target once during Baseline and zero times during Threat, while two other participants fixated the second target zero times during both Baseline and Threat.

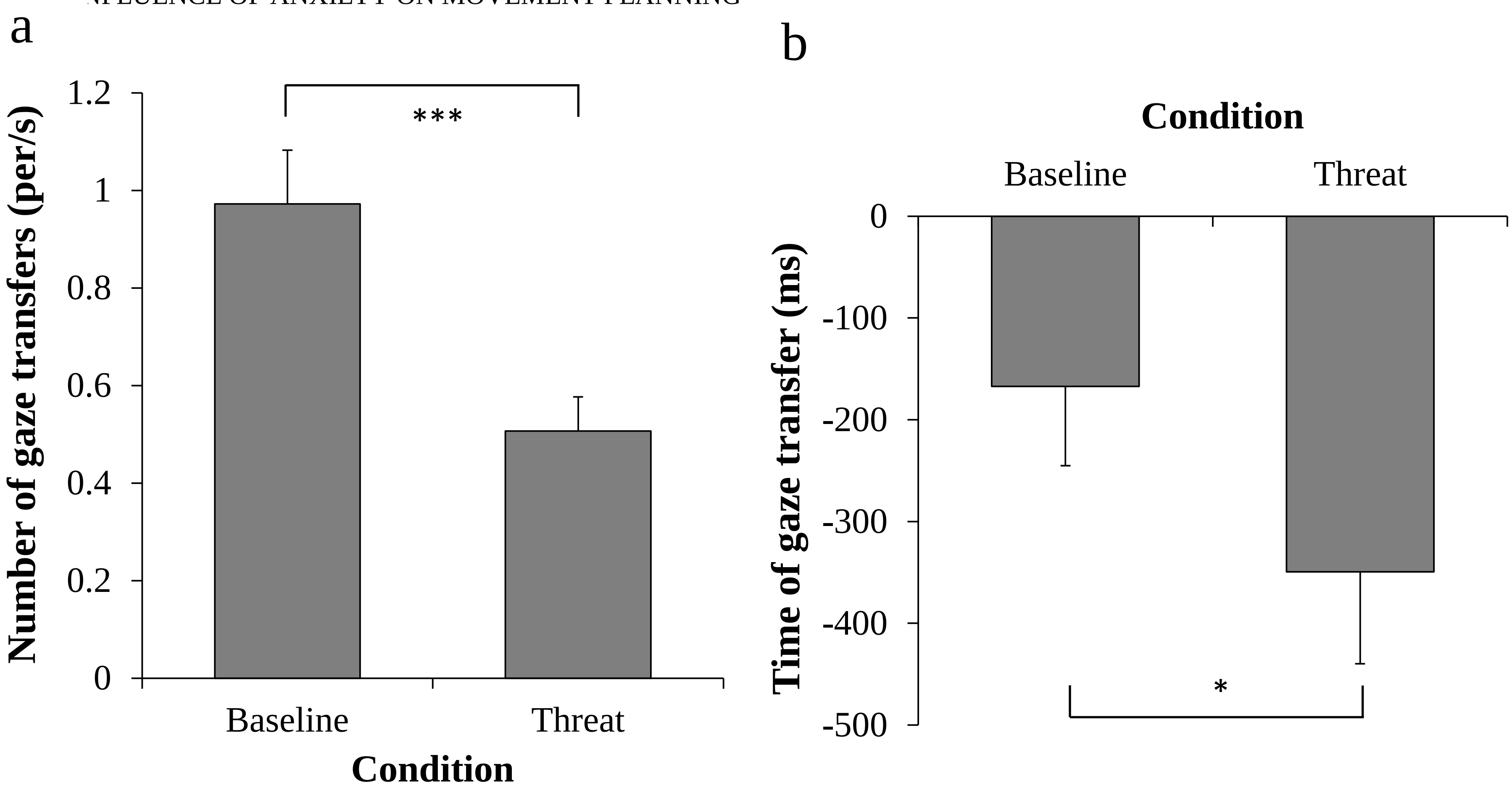

Figure 4a. Number of gaze transfers (per second) between different areas of the walking environment, under conditions of Baseline and Threat (mean ± standard error of the mean), ****p*<0.001

Figure 4b. Time of gaze transfer away from the first target (ms), relative to heel contact into the target, under conditions of Baseline and Threat (mean ± standard error of the mean), **p*<0.05. Note, a negative value denotes premature gaze away from the target before heel contact.

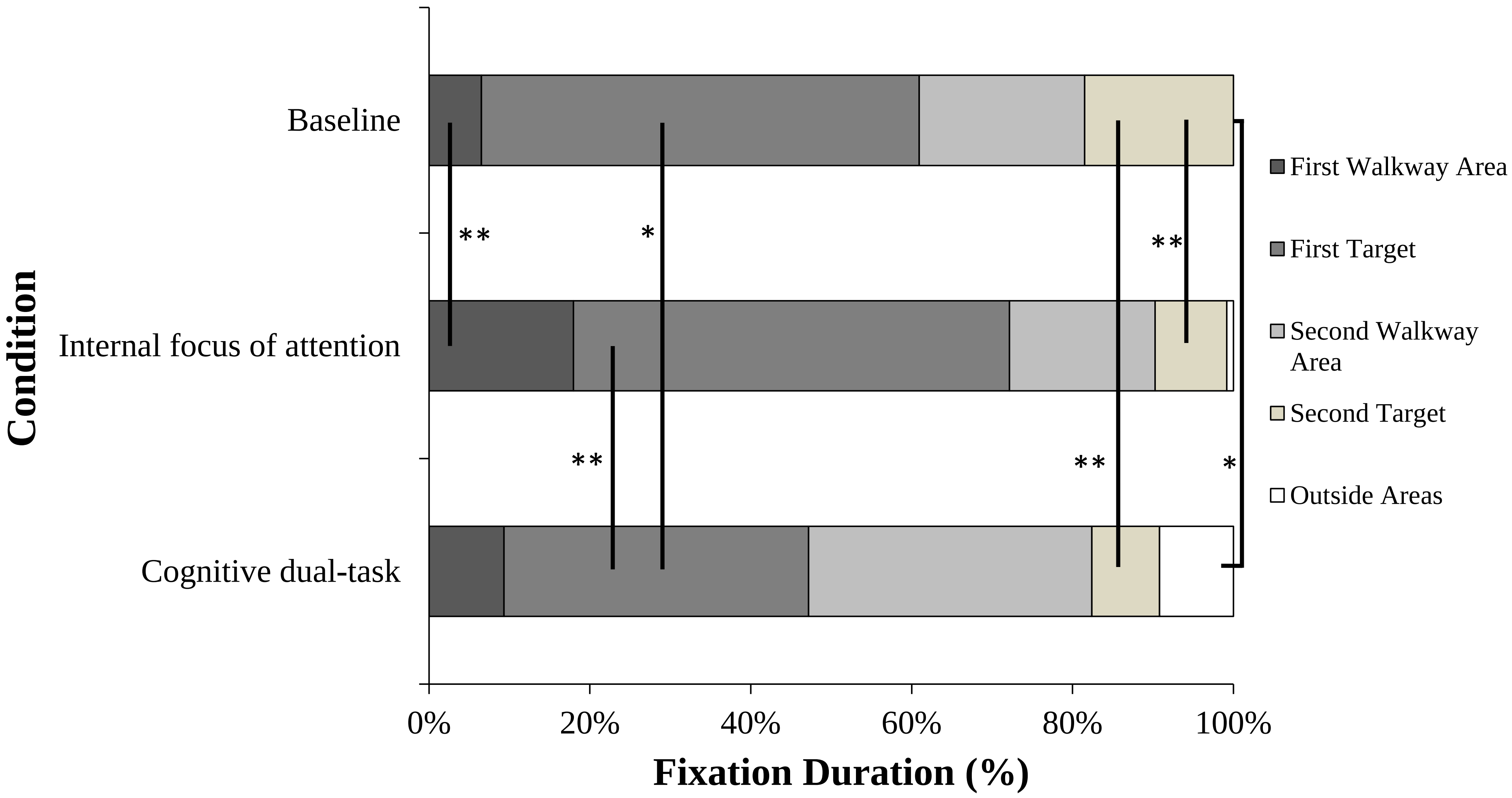

Figure 5. Duration (mean duration as a percentage) of time spent fixating the different areas of the walkway under conditions of Baseline, Internal focus of attention and Cognitive dual-task, *p<0.017, **p<0.01.

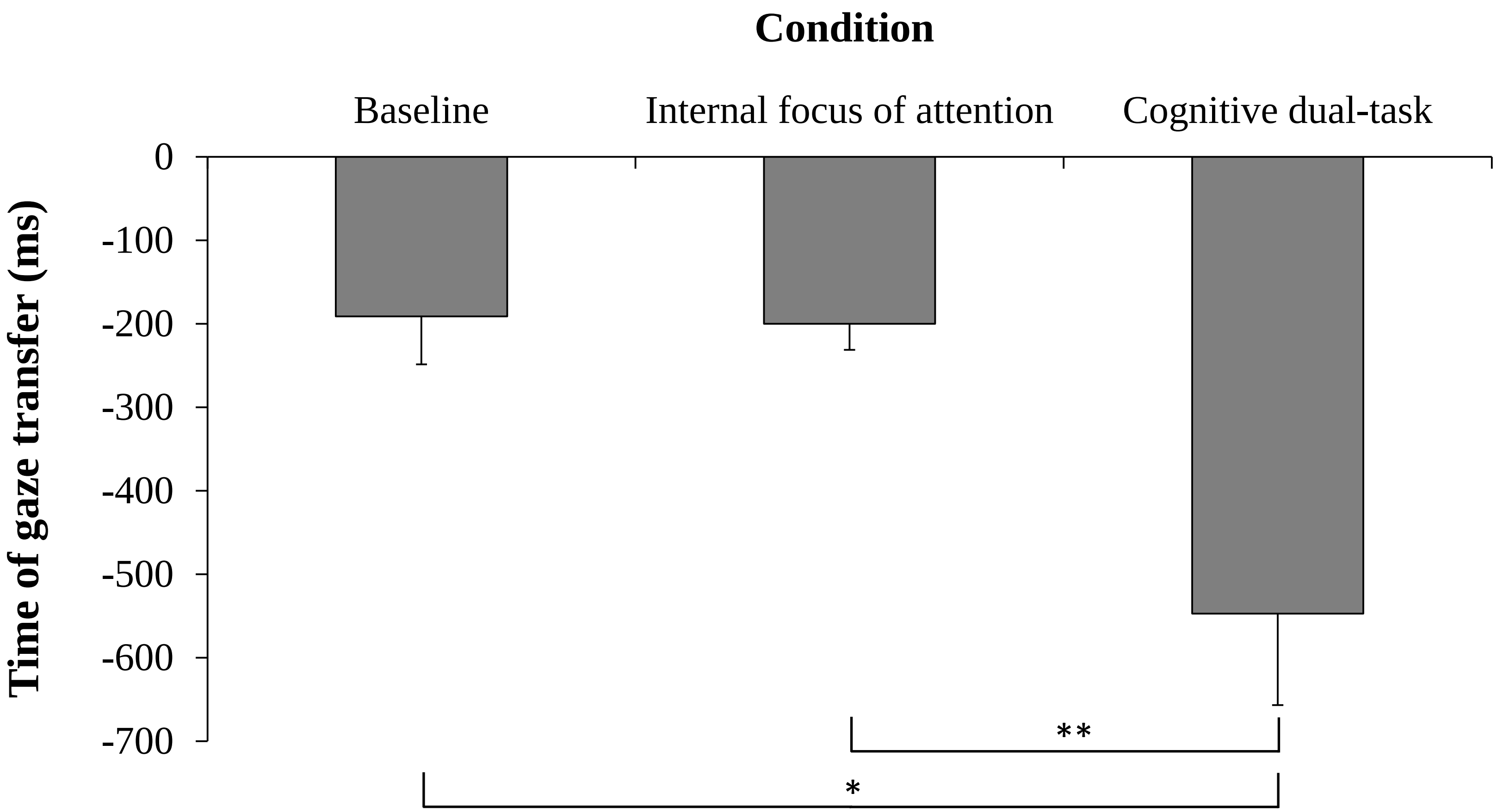

Figure 6. Time of gaze transfer away from the first target (ms), in relation to heel contact into the target, under conditions of Baseline, Internal focus of attention and Cognitive dual-task (mean ± standard error of the mean). Note, a negative value denotes premature gaze away from the target prior to heel contact, *p<0.017, **p<0.01.