Movement specific reinvestment and allocation of attention by older adults during walking

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Abstract

Older repeat fallers have previously been shown to have a higher propensity to consciously monitor and control their movements (i.e., reinvestment) than non-fallers, yet to direct their attention equally between their limb movements and the external environment during locomotion (Wong et al. 2009). Whether increased attention to their movements is a result of falling or originates from a prior inclination to reinvest remains unclear. In order to better understand the interaction between reinvestment and attention during locomotion this study examined the allocation of attention by older adults who had not fallen but displayed a high or low inclination for reinvestment. Twenty-eight low and twenty-eight high reinvestors were required to perform thirty walking trials. Their allocation of attention during walking was evaluated by asking tone-related attentional focus questions shortly after finishing each walking trial. High reinvestors were found to be more aware of their limb movements and less aware of the external environment. Low reinvestors, on the contrary, were more aware of the surrounding environment and less aware of their movement mechanics. Given that focusing internally to body movements have been proposed to utilise working memory capacity the ability of high reinvestors to pick up all the environmental information necessary for successful locomotion might be compromised and requires further examination.

Keywords: Reinvestment, older adults, locomotion, attentional focus

Introduction

Directing attention internally to body movements can disrupt performance (e.g., Beilock et al. 2002; Jackson et al. 2006; Masters et al. 1993). The Theory of Reinvestment (Masters 1992; Masters and Maxwell 2008) suggests that this happens when attention is allocated to processing task-relevant declarative knowledge in order to consciously control movements (i.e., reinvestment), which reduces the automaticity of the movements.

Masters et al. (1993) argued that the propensity to reinvest is a dimension of a personality, which inclines some people to be more likely than others to consciously monitor and control their movements. A general Reinvestment Scale (RS) was developed to measure individual differences in this inclination (Masters et al. 1993) and more recently a movement specific version was developed (the Movement Specific Reinvestment Scale, MSRS; Masters et al. 2005). The MSRS quantifies two dimensions of movement specific reinvestment, movement self-consciousness and conscious motor processing, and has been shown to have discriminant validity in a variety of populations, including those with Parkinson's Disease (Masters et al. 2007), stroke (Orrell et al. 2009) and older fallers (Wong et al. 2008). In all of these cases, members of the movement-affected population tend to score higher on the MSRS than age-matched controls.

Among older fallers, in particular, reinvestment may occur during locomotion. Declining physical and cognitive abilities make locomotion more demanding for older people in general, but previous experience of falling may cause more attention than normal to be allocated to monitoring and controlling limb movements. In previous work, Wong and colleagues (2009) asked repeat fallers and non-fallers to walk under high and low demand task conditions. After walking a short distance, participants were probed to answer questions about their focus of attention at the exact moment that a random probe occurred during the walk. The questions were irrelevant (control) or were designed to gain insight to internal (awareness of limb movements) or external (awareness of the environment) direction of attention during walking. Repeat fallers were more accurate at answering questions about their limb movements than non-fallers during high demand conditions (i.e., walking with a cup of water), but appeared also to be more accurate at answering questions about the external environment in which they had walked. Wong et al (2009) argued that "…elderly fallers have a greater tendency than non-fallers to divide their attention between the external environment and the internal mechanics of their movements" (p.921).

Given that reinvestment is a function of situational contingencies and personality disposition (Masters and Maxwell 2008), we were interested to examine whether non-fallers with a high disposition to reinvest allocate their attention similarly to fallers when walking in a demanding environment that requires accurate stepping and negotiation of obstacles. We therefore used the same paradigm as Wong et al. (2009) to examine the allocation of attention by older non-fallers with either a high propensity for movement specific reinvestment or a low propensity. We also modified Wong et al's (2009) external focus questions so that they did not refer to body parts. Wong et al (2009) asked external focus questions that were referenced by body location in the environment (e.g., "was your body in front of, or behind, the marker when you heard the tone?"), suggesting that the questions were not purely indicative of externally directed attention. This present study tested the following a priori predictions: (a) overall MSRS will be positively correlated with answering internal focus questions and negatively with answering external focus questions, (b) high reinvestors will answer internal focus questions significantly better than external focus questions, (c) low reinvestors will answer external focus questions significantly better than internal focus questions, (d) high reinvestors will answer internal focus questions significantly better than low reinvestors and (e) low reinvestors will answer external focus questions significantly better than high reinvestors.

Methods

Participants

Fifty six self-ambulatory older adults aged 65 or greater (*Mean age*=69.86 years, *SD*=3.87 years) were recruited from local elderly community centres and by word-of-mouth. Participants were excluded from participation if they reported a history of falling, scored less than 24/30 on the Cantonese version of the Mini-Mental State Examination scale, had static visual acuity worse than 20/40 vision, used walking aids, and/or reported a history of neurological impairment.

Ethical approval was obtained from the local ethics committee and written informed consent was collected from each participant.

Procedure

Following screening, the Chinese version of the MSRS (Masters et al. 2005; Wong et al. 2008, 2009) was administered. The MSRS consists of two subscales (five items each): conscious motor processing (e.g., "I am always trying to think about my movements when I carry them out") and movement self-consciousness (e.g., I'm concerned about my style of moving"). The items are rated on a 6-point Likert scale from *strongly disagree* (1) to *strongly agree* (6). Scores range from 5 to 30 points in each subscale and from 10 to 60 points overall, with higher scores indicative of higher propensity for reinvestment. Based on the scores on the scale, we divided participants into low (*N*=28; *Mean score*=17.04, *SD*=0.47) or high (*N*=28; *Mean score*=45.82, *SD*=1.29) reinvestment groups[1].

Participants completed 30 walking trials on a 4.8m pathway, which required them to step in the middle of a rectangular stepping target as accurately as possible before walking between two obstacles (see Fig 1). Each trial was initiated by a light positioned approximately 1 meter ahead of the starting line. Participants completed 20 trials during which an auditory probe was presented at random times during the walk. Following each trial, participants were required to answer either an internal focus question (e.g., "Was your left foot on the ground when you heard the tone?"), a body location question (e.g., "Were you past the target when you heard the tone?"), or an external focus question (e.g., "Was the light at the end of the walkway switched on when you heard the tone?"). There were 4 different questions in each category and none of the questions were repeated. During the remaining eight trials, an auditory probe was presented but no questions were asked. The order of these 20 trials was randomized.

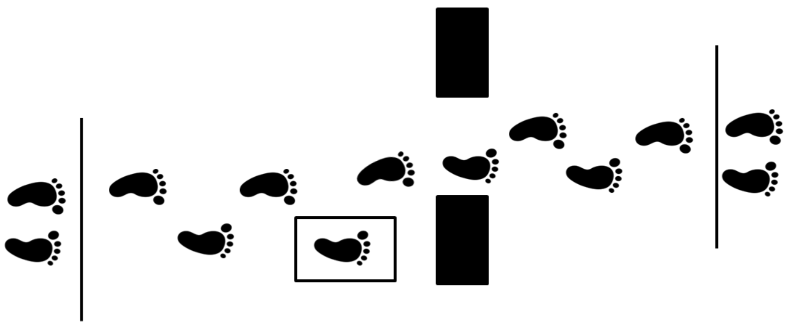

Fig 1. Schematic of the experimental set-up

Analysis

Percentage of accurate responses was computed for internal, body location and external focus questions. Due to the categorical nature of the data, non-parametric tests were employed. Spearman's rank correlation coefficient was used to analyse the relationship between MSRS and response accuracy in the three categories of question.Within-group differences in response accuracy between each category of question were assessed for high and low reinvestors separately, using the Friedman test followed by *post-hoc* Wilcoxon signed rank tests. Between-group differences in response accuracy were assessed for each category of question using Mann-Whitney U tests. A one-tailed test of significance was applied for outcomes for which a priori hypotheses were postulated. Effect size *r* was manually calculated based on the following equation:

$$r = \frac{Z}{\sqrt{N}}$$

[1] Prior to recruitment, a sub-sample of 76 older adults were asked to complete the MSRS. The scores were divided into thirds and the cut-off scores for upper and lower thirds were used for subsequent recruitment.

Results

Spearman's rank correlations revealed that MSRS was positively associated with response accuracy for internal focus questions (*r*=.27, *p*=.05) and negatively associated with response accuracy for external focus questions (*r*=-.29, *p*=.034). No association was evident for MSRS and body location questions (*p*=.731).

The Friedman test revealed significant differences in response accuracy for internal, body location and external focus questions in both high reinvestors ($\chi^2(2)=6.167$, *p*=.046) and low reinvestors ($\chi^2(2)=12.775$, *p*=.002)[2]. Wilcoxon signed rank follow-up tests revealed that high reinvestors were significantly less accurate when responding to external focus questions compared to internal focus questions (*Z*=-1.625, *p*=.05, *r*=.22). Response accuracy for questions about body location in the environment was equivalent to questions about internal focus (*p*> .05), but was significantly more accurate than for external focus questions (*p*< .05). For low reinvestors, significantly lower response accuracy was evident for internal questions compared to external questions (*Z*=-2.662, *p*=.004, *r*=.37). Response accuracy for questions about body location in the environment was equivalent to questions about external focus (*p*> .05), but was significantly better than for questions about internal focus (*p*< .05).

Mann-Whitney U tests revealed that high reinvestors were more accurate than low reinvestors when responding to internal focus questions (*U*=202, *p*=.003, *r*=.38) and were less accurate when responding to external focus questions (*U*=255.5, *p*=.031, *r*=.26). No differences were evident in response accuracy for body location questions (*U*=321, *p*=.287, *r*=.08) (Fig 2).

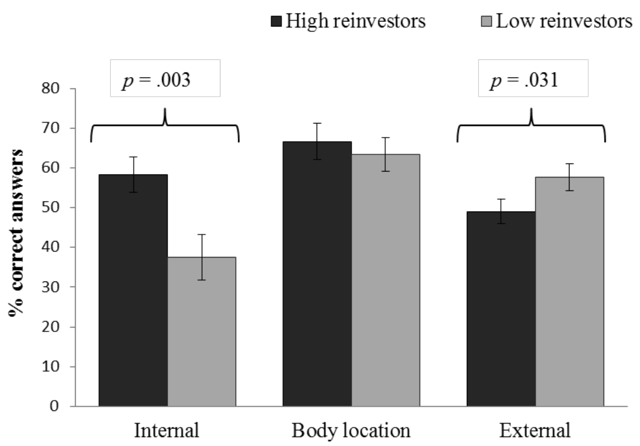

Fig 2. Mean (SE) of correct responses by high and low reinvestors to internal, body location, and external focus questions.

Discussion

Our data suggests that older adults who have not fallen, but nevertheless show a high propensity to consciously monitor and control their movements (as indicated by score on the MSRS), allocate attention internally to movement mechanics, whereas low reinvestors allocate less attention to their own limb movements and are more aware of the surrounding environment. In fact, high reinvestors were significantly less aware of the external environment but more aware of the limb movements than low reinvestors. These findings are not entirely consistent with the findings of Wong et al (2009), who suggested that older repeat fallers tended to divide their attention between internal movement mechanics and the external environment. Wong et al's (2009) external focus questions may have been flawed, however, providing an inaccurate picture of the way in which older adults direct their attention during locomotion. Alternatively, older people with a high inclination for movement specific reinvestment have different patterns of attention allocation compared to older repeat fallers during locomotion. Given that Wong et al showed that older repeat fallers also displayed a high propensity for movement specific reinvestment, we doubt that this is the case.

2 We excluded from analysis one of the external focus questions (i.e., "Did you feel the wind coming from a fan when you heard the tone?"). This question may not indicate purely external direction of attention as feeling wind on ones limbs may draw attention to them.

Reinvestment occurs in situations where people are highly motivated to perform effectively. Given that our walking task required accurate stepping and negotiation of potentially fall-threatening obstacles, it is not surprising that high reinvestors preferred to direct their attention to their movements in order to ensure safe completion of the walking task. The MSRS was positively associated with awareness of limb movements, but negatively associated with awareness of the external environment, providing further evidence that people with a higher propensity to reinvest preferred conscious control of their movements. Masters and colleagues (see Masters and Maxwell 2008) have argued that consciously attending to the process of moving uses resources from working memory, so older adults with a high predisposition to reinvest may be particularly at risk of missing external information that is relevant for successful locomotion, especially in constantly changing real-life settings. Low reinvestors, on the other hand, potentially used a more automatized form of locomotion control, reflected by low awareness of their limb movements, leaving resources available to monitor information in the external environment. Automatic movement execution is normally related to better performance; however, declines in physical and cognitive abilities during ageing may require older adults to attend to movement mechanics to ensure safe skill execution. In order to examine whether this holds true during locomotion in a challenging environment the relationship between reinvestment, allocation of attention and gait behaviour needs to be investigated.

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