CONTROL OF REACH-TO-GRASP REACTIONS DURING PERTURBED LOCOMOTION IN FAMILIAR AND UNFAMILIAR ENVIRONMENTS: WHEN DOES VISUAL FIXATION OF THE HANDRAIL OCCUR?

[1,2]Charles Cejka, [1]Tracy A. Lee, [1,3]William E. McIlroy and [1,2]Brian E. Maki
[1]Centre for Studies in Aging, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
[2]Institute of Medical Science, University of Toronto, Ontario, Canada; email: charles.cejka@utoronto.ca
[3]Department of Rehabilitation Science, University of Toronto, Ontario, Canada

INTRODUCTION

In many situations, successful execution of a balance-recovery reaction requires visual information about the environment. In particular, reactions that involve rapid limb movement, such as stepping or reaching, must be controlled to accommodate environmental constraints, i.e. objects or architectural features that can obstruct stepping or serve as handholds to grasp for support [1]. The location of these constraints, in relation to the body, continually changes as we move about in our daily lives.

In this study, we examined the mechanisms by which the central nervous system acquires the critical visuospatial information needed to execute rapid reach-to-grasp reactions in response to sudden, unexpected loss of balance. We hypothesized that: 1) the initial arm motion toward a handrail would rely on spatial information acquired via the visual scanning that automatically occurs when ambulating in an unfamiliar environment; and 2) the later phases of the arm movement and the prehension of the handrail would be guided by visual fixation of the rail occurring after initiation of the arm reaction.

METHODS

Testing involved a moveable 6.4m walkway, which was surrounded by curtains; a door at the entrance prevented any viewing of the walkway prior to the start of each trial. Eight healthy young adults (ages 24-35) were randomly assigned to either a *handrail* group (handrail located by a stair mounted near the end of the walkway; see Figure 1) or a *control* group (no objects on the walkway). In the first trial, subjects opened the door to view the walkway for the very first time, and then walked to the opposite end at a self-selected cadence. The walkway was controlled to unexpectedly translate forward during right single-support phase when the subject was in the vicinity of the handrail and stair (*handrail* group) or in a similar location (*control* group). A deception was used to ensure that the first perturbation was truly unexpected. In the remaining 59 trials, subjects knew that the walkway might move; however, walkway translations (forward or backward) occurred in only 30% of trials. During each trial, we monitored gaze behavior and arm motion.

RESULTS AND DISCUSSION

In the very first trial, *control* subjects tended to fixate on the travel path, with few eye movements directed toward the periphery. In contrast, *handrail* subjects fixated on the rail immediately after opening the door (mean dwell time: 483ms). During the subsequent ambulation, gaze was primarily directed at the travel path but typically did return to the handrail one or more times. When the perturbation occurred, all four *handrail* subjects initiated rapid lateral arm movement toward the rail. In all cases, gaze was not directed at the rail at perturbation onset, but was redirected toward the rail after the initiation of the reaching movement. It is clear that the initial arm motion was not simply a stereotyped response, since the predominant direction of the motion in the *control* group was distinctly different (forward rather than lateral).

With repeated trials, reaching movements occurred less frequently (11% of perturbation trials) and the gaze behavior more closely resembled that of the *control* group (i.e. gaze directed primarily along the travel path). In 3 of the 8 trials where reaching occurred, there was no visual fixation of the rail at any point prior to perturbation onset.

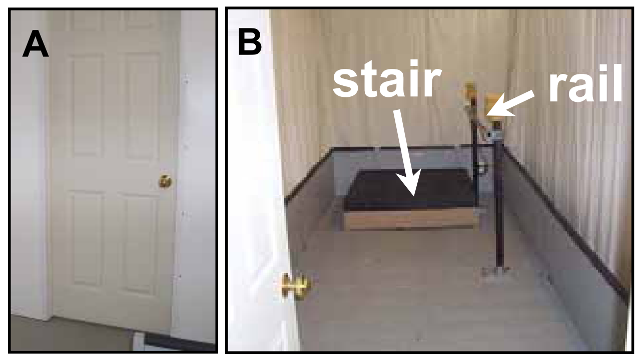

Figure 1: View of moveable walkway (*handrail* subjects) from the entrance, with door closed (A) and open (B).

CONCLUSIONS

These findings suggest that a pre-formed visuospatial map of the surroundings is used to initiate rapid reach-to-grasp reactions. This map is formed automatically (even when there is no expectation that a perturbation may occur) via visual scanning when ambulating in an unfamiliar environment. The capacity to utilize spatial information 'remembered' from previous trials may reduce the need for visual scanning, i.e. when the environment is familiar. Online visual feedback may be used later in the trajectory to guide the arm to its endpoint and/or assist in prehension of the rail. Use of a pre-formed map presumably serves to facilitate more effective balance recovery by allowing an appropriately-directed arm movement to be initiated as rapidly as possible, thereby avoiding delays that would occur if instead the visual scanning of the environment had to be performed after perturbation onset [1].

ACKNOWLEDGMENTS

Supported by the Canadian Institutes of Health Research.

REFERENCE

1. Ghafouri M, et al. *Exp Brain Res* **155**, 532-536, 2004.