THE INTERACTION BETWEEN POSTURE AND COGNITION DURING A MANUAL FITTING TASK

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INTRODUCTION

An increasing amount of research has demonstrated that postural fluctuations (sway) are modulated based on the constraints of a concurrent suprapostural task [1, 2] For example, when performing a suprapostural precision manual [3] or visual fixation task [1], individuals reduce their postural sway below quiet standing baseline conditions. This reduction aids the completion of the task because any extraneous postural movements impede accuracy or visual acuity. Although a reduction in postural sway sometimes aids the completion of a suprapostural task, some degree of postural sway can be functional [4]. Specifically, postural sway can be exploratory in that it generates sensory information regarding the environmental landscape over which movements are or will be occurring [5]. It therefore appears that the expression or suppression of sway in a healthy postural system is dependent on the constraints and goals of a suprapostural task.

Research has also shown that performing a concurrent cognitive task while standing influences the dynamics of postural sway. For example, when performing a digit memorization task, participants systematically reduce postural sway as the number of digits to be memorized increases [6].

Although both cognition and the constraints of a suprapostural task can influence postural sway, to date there has been little research examining how postural sway is affected when both a cognitive and manual task are simultaneously performed. This is important because many tasks performed in everyday life have both a manual and cognitive component. It is possible that performing a cognitively demanding task reduces the ability of the postural system to appropriately modulate postural sway based on the constraints of the suprapostural task. The purpose of this study was therefore to examine changes in postural dynamics as participants performed a precision manual fitting task while simultaneously performing a digit memorization task. It was hypothesized that as individuals performed a concurrent memorization task, they would be less able to modulate postural movements based on the constraints of the manual precision task.

METHODS

Participants (8 males and 7 females; aged 18-25) were required to fit a block (88.9mm X 88.9mm) through either a large (130mm) or small (100mm) opening while memorizing 0, 2, 4, 6 or 8 digits (Figure 1). The order in which the small and large opening trials were presented was counterbalanced between participants. Within each large and small opening block, the number of digits to be memorized was presented in a random order. Each trial was performed five times (50 total trials).

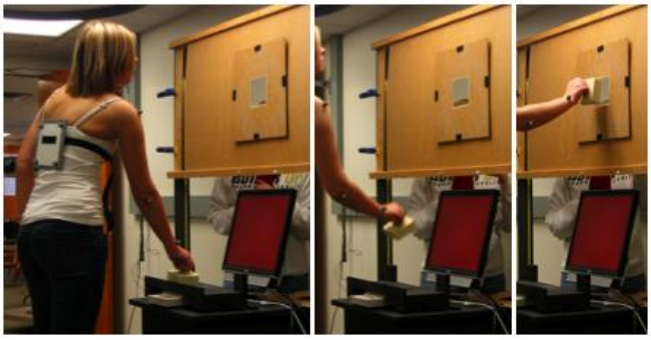

Figure 1: Example of a participant fitting the block through the small opening. The sequence of numbers to be memorized was displayed on the computer screen below the fitting board.

During each trial the participant memorized digits that were displayed on a computer screen for 10 seconds. After ten seconds, the computer screen turned red and the participant was required to accurately fit the block through the opening. Once the block was through the opening, the computer

produced a "ring" sound and the participant repeated the digits they had memorized. Postural stability over the course of each trial (the time between when the block was first picked up until it passed through the opening) was analyzed by calculating postural time-to-contact from the center of pressure (CoP) time series (collected at 120Hz from an AMTI force platform). Postural TtC is a measure that calculates the time it would take for the CoP to reach the base of support (boundaries of the feet) given its instantaneous position, velocity and acceleration [7]. Since the coordinates of the base of support are used in the TtC calculation, it is well suited for measuring postural stability during dynamic tasks where the CoP shifts within the base of support.

RESULTS AND DISCUSSION

The first conclusion to emerge from the results was that postural TtC increased (posture became more stabilized) when fitting through the small opening compared to when fitting through the large opening ($p<.05$). This was especially true in the later parts of the fit cycle (as the block is being fit through the opening) when the precision requirements of the task were greater (Figure 2). The systematic increase in postural TtC across the duration of the fitting cycle suggests that individuals are capable of modulating postural stability based on the instantaneous precision demands of the task. When the precision requirements were more difficult (e.g. towards the end of the fitting movement), posture became more stabilized. This may have been due to a suppression of exploratory postural movements. However, when the precision constraints of the fit were less demanding, posture was not as stabilized. This may be because the postural system allowed some exploratory postural movements to be expressed.

The second conclusion to emerge from the results was that performing a concurrent memorization task did not appear to influence postural stability as the participant performed a manual fitting task (Figure 2; $p>.05$). This finding was counter to the original hypothesis that performing a memorization task would interfere with the ability of the postural system to exhibit constraint-specific modulations in postural stability. This result was surprising because previous research has shown that during quiet standing paradigms postural sway decreases when individuals are asked to memorize a series of numbers [6]. The methodologies were virtually identical between our research and previously published research, with the exception that our participants performed a fitting task while memorizing numbers. It is possible that performing a manual fitting task while memorizing a series of numbers may draw attention away from the task of maintaining upright stance. Whereas, participants focus more attention on stance when instructed to stand and memorize numbers (causing a decrease in postural sway). Future work will examine if simultaneously performing a cognitive and manual task impedes the ability of the postural system to modulate postural sway in elderly subjects. It is possible that such multitasking is more difficult in elderly subjects compared to the current pool of college-aged individuals.

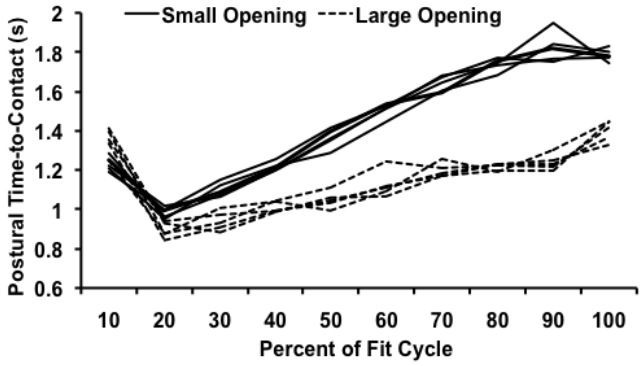

Figure 2: Postural time-to-contact over the reach cycle when fitting through the small (solid lines) and large (dotted lines) opening. Larger numbers represent a greater degree of postural stabilization. Each line represents one of the cognition levels.

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