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Older Adults Retain the Ability to Predict External Perturbations Using Auditory Cues Only

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Introduction

To maintain balance and prevent destabilization, humans utilize anticipatory postural adjustments (APAs) prior to the postural perturbations based on predictions and past experience. APAs involve the activation and inhibition of the trunk and leg muscles and a shift of the center-of-pressure (COP) position [1]. The generation of APAs majorly relies on the availability and accuracy of visual information. However, our previous work showed that young adults could rely on an auditory cue only to generate APAs for an external perturbation similar to that when the visual information was available [2]. Older adults generally have diminished APAs and consequently diminished postural control when postural perturbations occur [3]. In this study, we aimed to train older adults to rely on an auditory cue to generate APAs in response to an external perturbation, and examine the retention of this learning effect after 1 week.

Method

Five older adults (3M/2F, mean age 70.3±6.6 years) took part in this pilot study. They were instructed to stand on a force plate and be prepared for an pendulum hitting their front shoulders bilaterally. An additional weight (3% of the body weight) was attached to the pendulum (Figure 1). During the first visit, participants received the external perturbation while vision was available (BLV, 5 trials), and while vision was blocked (BLNV, 5 trials). Then they received training (Tr, 50 trials) when vision was blocked but an auditory cue signalling the moment of the pendulum release was provided. After 1 week, retention (Re) was tested when participants received the perturbation with the vision blocked but the same auditory cue was provided (10 trials).

Figure 1

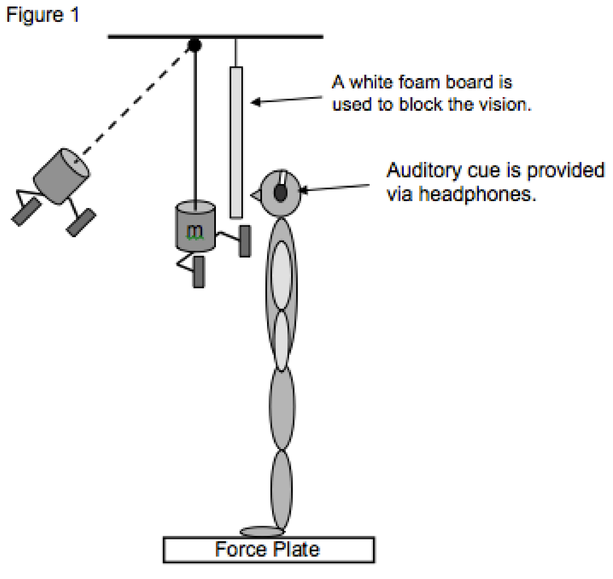


Figure 2

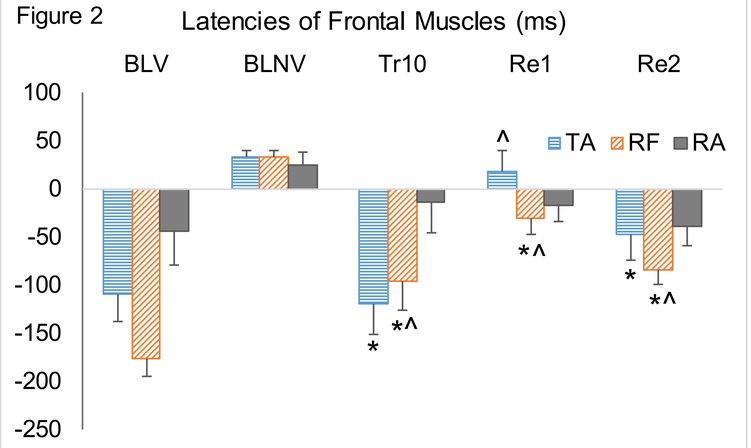


Figure 3

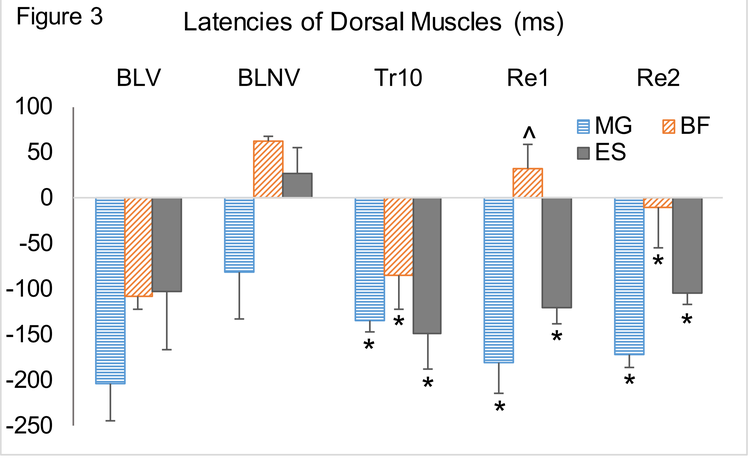
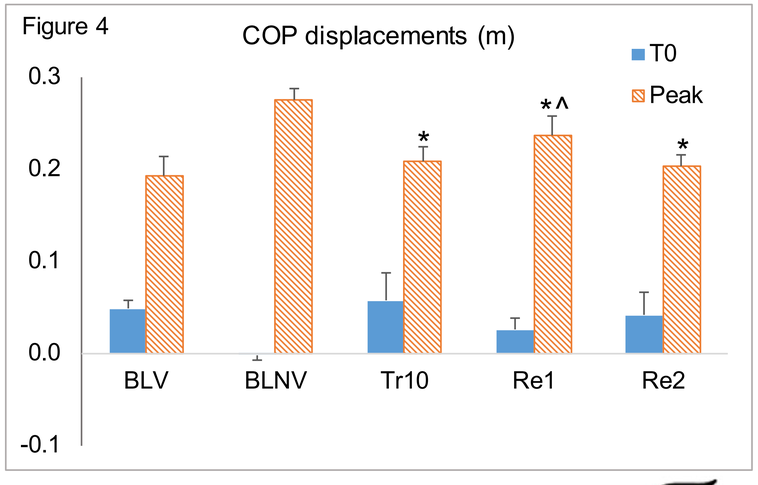


Figure 4



Method

The moment of pendulum impact (T0) was identified using an accelerometer attached to the pendulum. Muscle activities were recorded from the right tibialis anterior (TA), medial gastrocnemius (MG), rectus femoris (RF), biceps femoris (BF), rectus abdominus (RA), and erector spinae (ES). Muscle latency was defined as the first time point within a window of 50ms that the EMG amplitude was consistently greater (activation) than or smaller (inhibition) than its baseline value (-500 to -350ms) ± 2SD. The COP displacements in the anterior-posterior direction at T0 and its peak value after T0 were identified.

Data were organized into 5-trial blocks. Ten trials that tested the retention during the second visit were organized into two blocks (Re1 and Re2). Data from the BLV, BLNV, last block of training (Tr10), and two blocks of retention (Re1 and Re2) were used for further analysis. A series of one-way repeated measures ANOVAs were conducted. Statistical significance was set at $\alpha = 0.05$.

Results and Discussion

In BLV condition, latencies of the muscles were detected prior to T0. In the BLNV condition, the latencies were detected mostly after T0. In the Tr10 and Re2 conditions, latencies were comparable to that of the BLV condition. Statistical analysis showed significant differences among conditions for the latencies of TA, MG, RF, BF, and ES (all $p<0.05$). In Figure 2-4, * denotes a difference compared to the BLV condition and ^ denotes a difference compared to the BLNV condition.

When vision was available (BLV), older adults moved their COP posteriorly prior to the perturbation impact (APA phase) and demonstrated a small peak displacement after the physical contact of the pendulum. In the BLNV condition, the COP at T0 was close to 0, and the peak displacement was larger. Statistical analysis showed significant differences among conditions for COP peak ($p<0.05$). Values are presented in meters, and positive values represent posterior displacements

These results suggest that after only one session of repetitive training, older adults could learn to generate APAs for an otherwise unpredictable postural perturbation relying on an auditory cue, which also resulted in reduced postural disturbance after the perturbation impact. After 1 week, they partially retained this ability; but they might need more than 10 repetitions of enforcement to fully regained this ability.

Significance

Auditory cues could be used in a training protocol to improve the generation of APAs and consequently to improve overall postural control in older adults.

References

[1] Bouisset & Zattara. J Biomech 20:735-742, 1987.
[2] Liang et al. Exp Brain Res (In press) 2020. Doi: 10.1007/s00221-020-05738-6.
[3] Kanekar & Aruin. Exp Brain Res 232, 1127-1136, 2014.