THE IMPACT OF ECHOLOCATION ON POSTURAL CONTROL

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Summary

The role of auditory perception in postural control remains largely unexplored and existing models do not integrate acoustic signals while past research has yielded to inconsistent results. This study examines how echolocation influences postural stability and provide new insights into the involvement of auditory cues in postural control.

Introduction

Postural control relies on multisensory integration [1], traditionally involving visual, vestibular, and somatosensory inputs. Recent studies explore whether auditory information contributes to balance regulation. However, findings remain inconsistent due to methodological differences, particularly in postural variables analyzed and the type of auditory stimuli considered. While most studies focus on direct sound sources, this research examines the role of echolocation [2], widely used by visually impaired individuals. It aims to determine whether auditory cues influence posture and if individual echolocation ability correlates with postural regulation.

Methods

Eleven adults (23±2.2 yrs) stood barefoot and blindfolded on a forceplate located in the middle of a semi-anechoic room. The postural variable analyzed (CoP-CoM) was obtained from a Kistler forceplate synchronized with 8 Qualisys Optoelectronic cameras (Fs:100Hz). This variable measures the positional difference between center of pressure (CoP) and body center of mass (CoM) at each instant and is closely correlated with the horizontal acceleration of the CoM [3]. To simulate various acoustic environments, we developed an automated device with a reflective circular target, mounted on an adjustable height stand facing the participants and able to move away or far from them. A Visaton loudspeaker (3W) located on participant's head emitted synthesized white sound as stimuli. Six acoustic conditions were randomized (4 trials/cond, 20s): NS, SS, FA, NE, AW and TW (Figure 1**A**). To analyze the impact of the acoustic condition on the perception and on RMS CoP-CoM variable (mm) in the AP and ML directions, logistic regression with random effects and multiple comparisons with controlled family-wise error rate were performed. P value was fixed to 0.05.

Results and Discussion

The results of the multiple comparisons revealed significant differences in the probability of accurate perception between specific conditions (Figure 1**B**). Moreover, the acoustic condition factor has a significant impact on the RMS (A/P) but multiple comparisons highlighted significant differences only when the target was close to the participant or when it was moving (Figure 1**C**).

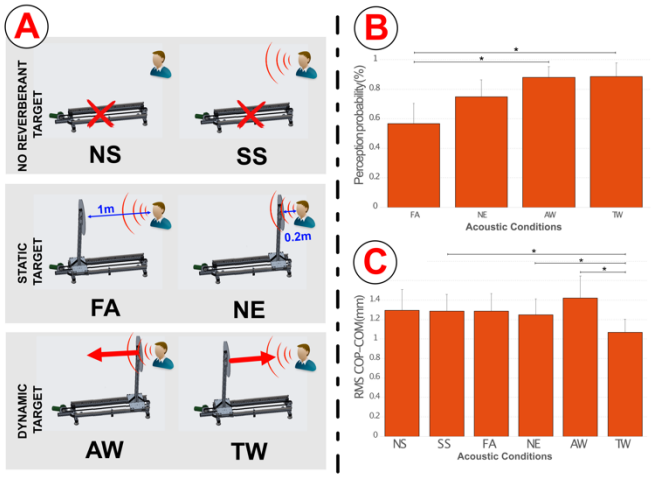

Figure 1: **A**. Six conditions: NS; No Sound; SS: Sound Source; FA: Far; NE: Near; AW: away; TW: Toward. **B**: Perception probability w/r to acoustic conditions. **C**: RMS CoP-CoM (mean±sd) w/r to acoustic conditions in AP axis. *p<0.05

This study confirms the work on echolocation by Tirado [4], who used a similar setup, but extends their findings to postural control. Our results showed that moving targets improved perception accuracy compared to stationary targets. Dynamic acoustic cues were found to enhance postural stability, as participants exhibited less sway when the target moved toward them. Finaly, while our study highlighted the stabilizing role of dynamic auditory cues, further research is needed to explore the link between auditory perception and postural control, particularly in individuals with experience in echolocation techniques.

Conclusions

Acoustic information, particularly through echo perception, contributes to postural control alongside visual, proprioceptive, and vestibular inputs, but to a lesser extent, with dynamic auditory cues playing a more significant role than static ones.

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