Contribution of auditory feedback to postural stability
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Introduction
• Balance control is a multisensory process that is known to rely on visual, vestibular, and somatosensory feedback.
• Auditory information influences balance, but less is known about the mechanisms underlying this process, especially the role of auditory noise.
• Hypothesis: Sway variability will be reduced with exposure to auditory white noise, and the effect will be greater in the eyes open condition than in the eyes closed condition.

Methods
• We examined the effect of auditory noise on postural sway during relaxed standing by tracking center of pressure (CoP) using a force platform (sampling rate = 2,000 Hz).
• 19 healthy participants (12 females) without hearing loss, neurological disorder, arthritis, orthopedic conditions, recent injuries, or balance disorders.
• Tested eyes open and eyes closed, during silence or white noise presented through headphones at 75 dB.
• Used radial sway of CoP, which is calculated from the Anterior-Posterior and Medial-Lateral sway: \( r = \sqrt{x^2 + y^2} \)

Results

SWAY VARIABILITY

Fig. 1 Center of pressure displacement exhibited by one subject in eyes closed/open and silent/noise conditions.

Fig. 2 A) Radial sway variability in eyes closed/open and silent/noise conditions. Error bars represent ±1 standard deviation from the mean.

Fig. 3 Nonlinear measures of sway. Error bars represent ±1 standard deviation from the mean. Recurrence quantification analysis (delay = 40, embedding dimension = 4, radius = 10) revealed that A) % determinism decreased with vision (p = .003) and noise (p = .045), B) % recurrence decreased with noise (p = .031), and C) entropy decreased with vision (p = .014) and noise (p = .006). There were no vision × noise interactions. Determined fluctuation analysis (DFA) revealed that the sway patterns exhibit antipersistent fBm (1.18±1.5), which is consistent with previous work on postural sway. There were no differences between conditions.

ORIENTING REFERENCE
• Moving reference in auditory and somatosensory feedback can reduce sway variability.
• We used headphones to eliminate location cue.

STOCHASTIC RESONANCE
• Introducing noise can enhance evoked response in the peripheral nervous system.
• Has been shown in vision, audition and mechanical sensory perception.

Conclusions
• We found reduced CoP variability in the presence of auditory noise, which is similar to the reduction in variability with vision.
• Nonlinear time series analysis revealed that auditory noise has an additive effect, independent of vision, on postural stability during the trials.
• For feedback based processes, noise interacts with vision, whereas for open-loop/exploratory processes, the effect of noise is additive.
• Possible explanation: stochastic resonance.

Future Directions
• We plan to explore the role of noise in reducing the postural sway variability in older adults and those with balance disorders due to central nervous system dysfunction.

TIMESCALES OF SWAY

Fig. 4 Radial sway variability in low and high frequencies in eyes closed/open and silent/noise conditions. Error bars represent ±1 standard deviation from the mean. Filtering was performed using a dual-pass, second-order Butterworth filter with a cutoff frequency of 0.3 Hz.

Fig. 5 A) In low frequency sway, there was an effect of vision (p = .009) and noise (p = .012), with a vision × noise interaction (p = .003). B) In high frequency sway, there was an effect of vision (p < .001) and noise (p < .001), with no vision × noise interaction.