Contribution of auditory feedback to postural stability

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Introduction

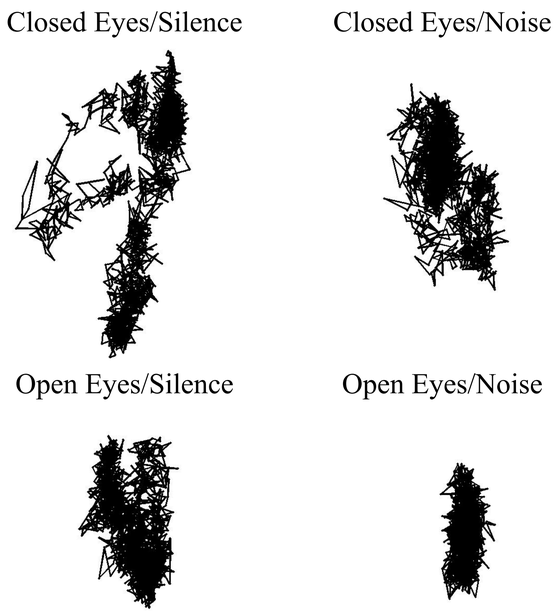
- Balance control is a multisensory process that is known to rely on visual, vestibular, and somatosensory feedback.
- Auditory information influences balance, but less is known about the mechanisms underlying this process, especially the role of auditory noise.
- **Hypothesis: Sway variability will 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

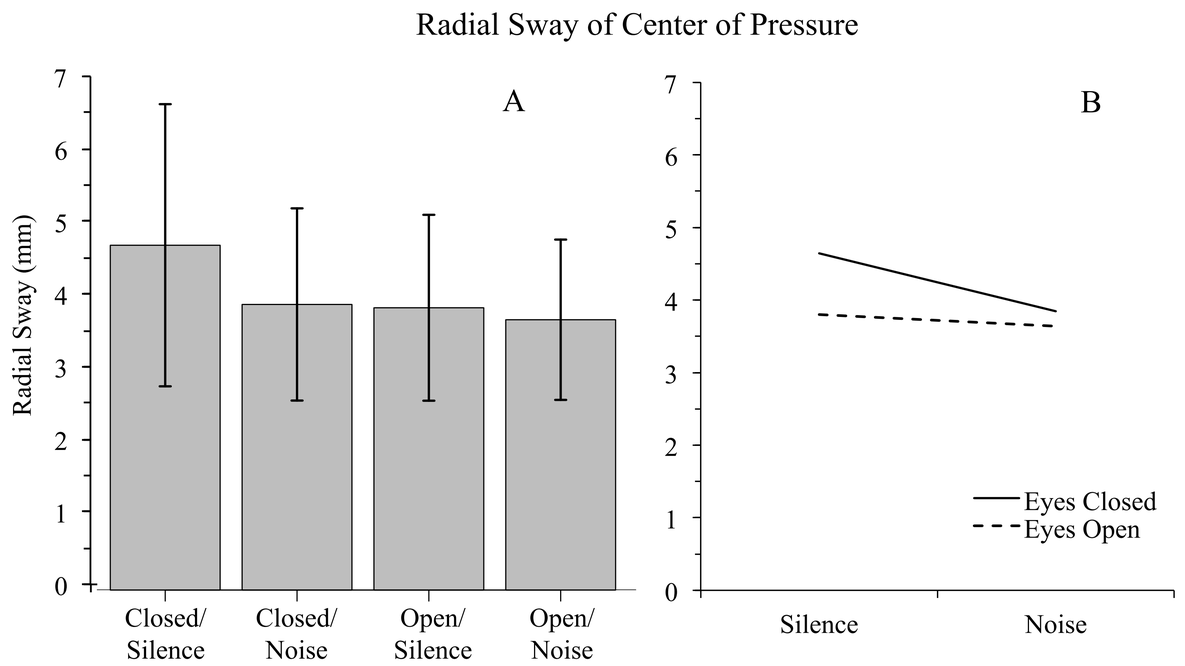
- We examined the effect of auditory noise on postural sway during relaxed standing by tracking center of pressure (CoP) using a force platform (sampling rate = 2,000 Hz).
- 19 healthy participants (12 females) without hearing loss, neurological disorder, arthritis, orthopedic conditions, recent injuries, 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

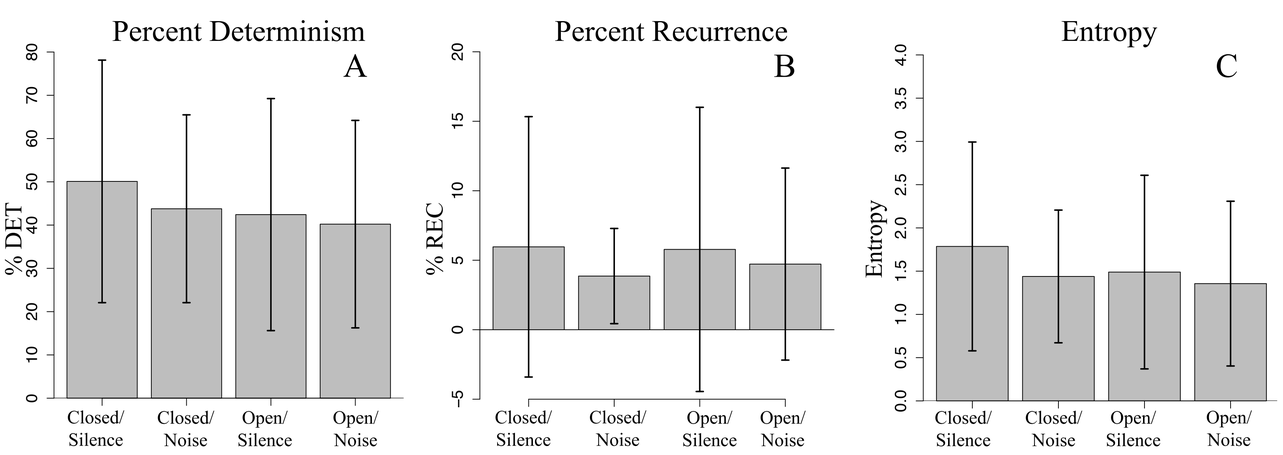


← **Fig. 1** Center of pressure displacement exhibited by one subject in eyes closed/ open and silent/noise conditions.



🡅 **Fig. 2** A) Radial sway variability in eyes closed/open and silent/noise conditions. Error bars represent ±1 standard deviation from the mean. Variability decreased with vision (p = .006) and auditory noise (p = . 017). B) Vision and noise contribute interactively to sway (p = .026).

SWAY TEMPORAL PATTERNS

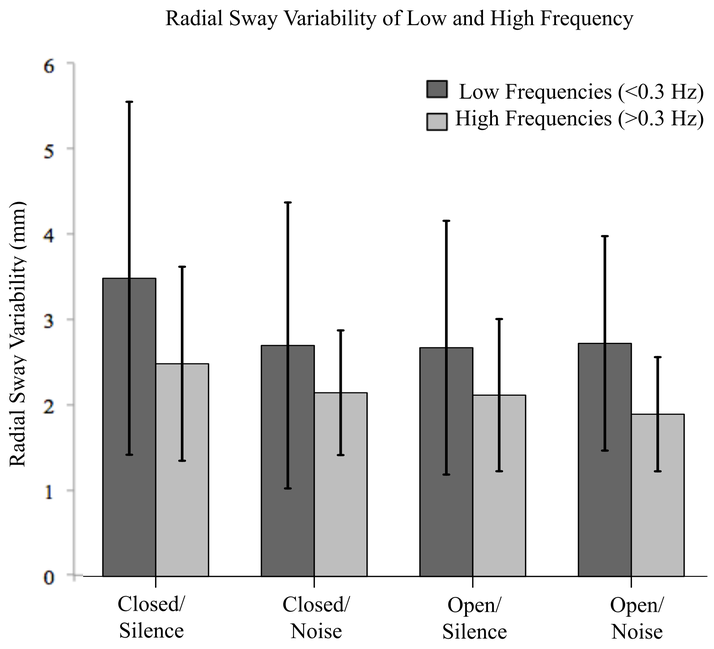


🡅 **Fig. 3** Nonlinear measures of sway. Error bars represent ±1 standard deviation from the mean. Recurrence quantification analysis (delay = 40, embedding dimension = 4, radius = 10) revealed that A) % determinism decreased with vision (p = .003) and noise (p = .045), B) % recurrence decreased with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

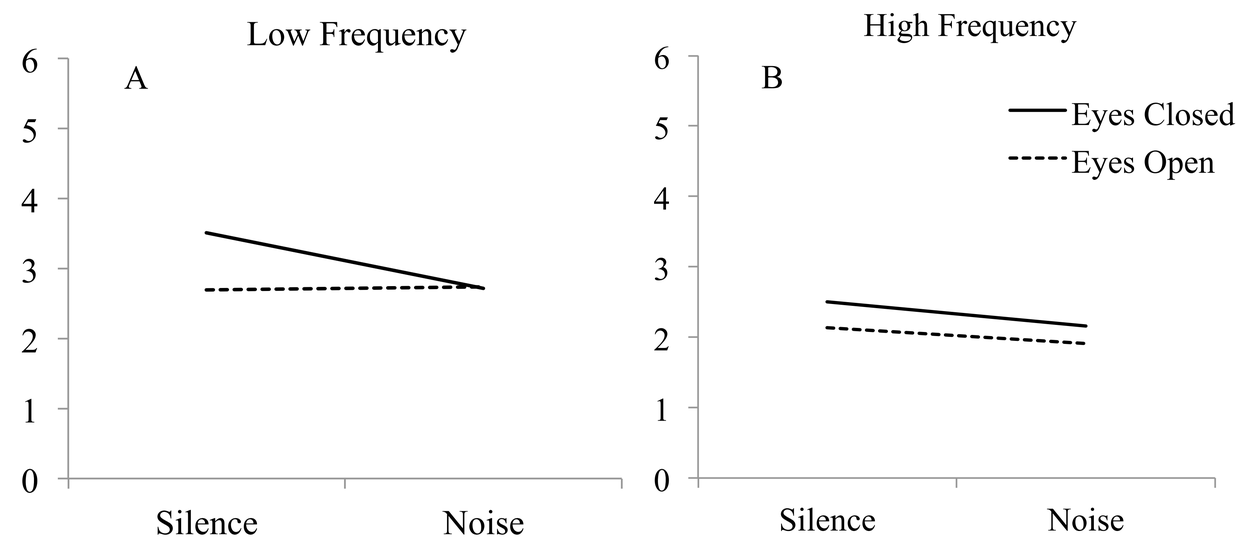
Results

TIMESCALES OF SWAY

- Low and high frequency components of sway are thought to reflect feedback driven and spontaneous aspects of sway, respectively.



← **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.



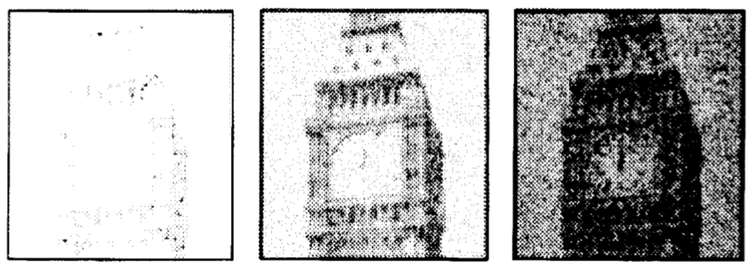
🡇 **Fig. 5** A) In low frequency sway, there was an effect of vision (p = .009) and noise (p = .012), with a vision × noise interaction (p = .003). B) In high frequency sway, there was an effect of vision (p < .001) and noise (p < .001), with no vision × noise interaction.

ORIENTING REFERENCE

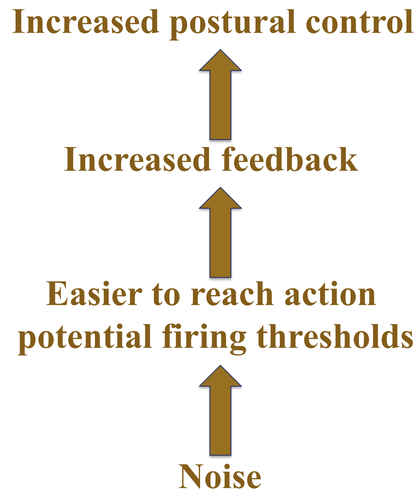
- Moving reference in auditory and somatosensory feedback can reduce sway variability.
- We used headphones to eliminate location cue.

STOCHASTIC RESONANCE

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



Simonotto, Riani, Seife, Roberts, Twitty, & Moss (1997)



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 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.

For a PDF of the poster: