EFFECTS OF 'TONE-IN-NOISE' MOVING VISUAL SCENES ON POSTURAL SWAY

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INTRODUCTION

The use of moving visual scenes to evoke postural responses is a practical method of experimentally examining the sensory integration processes related to posture, as it provides a means of manipulating visual input in a controlled fashion. This approach has been utilized to investigate postural phenomena such as sensory conflict (Kuo et al. 1998) and sensory reweighting (Peterka, R. 2002), as well as *adaptation* – which is a transient decrease in postural sway that has been observed in subjects exposed to periodic moving visual scenes (Loughlin et al, 1996). Evidence of adaptive behavior in response to periodic inputs suggests that predictive mechanisms may exist in the postural control loop. A useful next step would be to determine if non-periodic inputs elicit similar adaptive behavior. As such, *the purpose of this study is to experimentally examine the effect of 'tone-in-noise' moving visual scenes on postural sway adaptation*.

METHODS

Postural sway responses to various moving visual scenes were examined in 6 healthy young adults. Tests were performed in the BNAVE, a custom built virtual environment that projects computer generated images onto several adjoining screens (Jacobson et al. 2001). Subjects stood comfortably in an upright position, with arms folded across the chest, and bare feet placed side-by-side on a force platform (NeuroCom Inc., Clackamas OR), while viewing a bullseye-and-checkerboard pattern that moved back and forth in a periodic or pseudorandom fashion (Fig 1). There were a total of six scene movements, each of which was a tone-in-noise time series that was created by combining a 0.3Hz sinusoid with gaussian white noise (bandpassed, 0.05-0.5Hz) at one of six signal-to-noise ratios (SNR): –inf (i.e. noise), 0dB, 3dB, 6dB, 12dB, and +inf (i.e. sinusoid). Each trial lasted 80 seconds: 60 seconds of scene movement bounded at beginning and end by 10 seconds of a stationary scene. The six movements were presented randomly, and shown only once. Subjects rested for 2 minutes after each trial.

Postural responses were examined through measurements of head, hip and center-of-pressure (COP) displacements (collected with a Polhemus electromagnetic tracking system (20Hz) and the NeuroCom platform (100Hz), respectively). The anterior-posterior (AP) root-mean-square (RMS) of these data was used to compare responses among the six tone-in-noise populations, and to determine if sway adaptation occurred.

Figure 1: Subject standing in the BNAVE

RESULTS AND DISCUSSION

Visual data inspection and cross-correlation analyses revealed that AP head, hip and COP displacements were in phase with one another for all trials, indicating that the body swayed as an inverted pendulum (Fig 2).

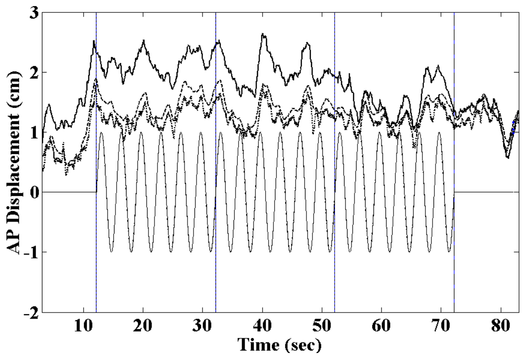

Figure 2: AP head (top), hip (mid) and COP (bot) responses to the 0.3Hz sinusoid (also shown).

Power spectra for the head data revealed that (1) the tone-in-noise moving scenes evoked sway responses near the stimulus frequency (primarily the 0.3Hz sinusoid), and (2) mean sway frequency appeared to decrease with decreasing SNR of the tone-in-noise scenes.

Prior to the onset of visual scene motion, RMS values were similar for all six tone-in-noise populations, likely because the motions that differentiate the scenes had not yet occurred (Fig 3). RMS values were higher and more varied among the tone-in-noise groups during periods of scene motion, but a consistent trend was not apparent. Overall, there was no discernable correlation between visual tone-in-noise SNR and sway RMS in any of the 20-second intervals.

Adaptation did not occur. RMS did not decrease over the course of the 60 second trial, for any of the tone-in-noise conditions (Fig 3). In fact, RMS values increased throughout the moving scene portion of the trials for three of the six tone-in-noise populations (sin, 12dB, and 0dB).

SUMMARY

There was no discernable correlation between tone-in-noise SNR and sway RMS. In addition, adaptation of the sway response was not observed, even in the sinusoidal scene population, which is in contrast to earlier findings (Loughlin et al. 1996). This may be due in part to the inability of a summary statistic like RMS (applied over 20 second intervals) to capture dynamic aspects of the time-varying adaptation process. A method such as time-frequency analysis is better suited to this task, and will be utilized in future analyses.

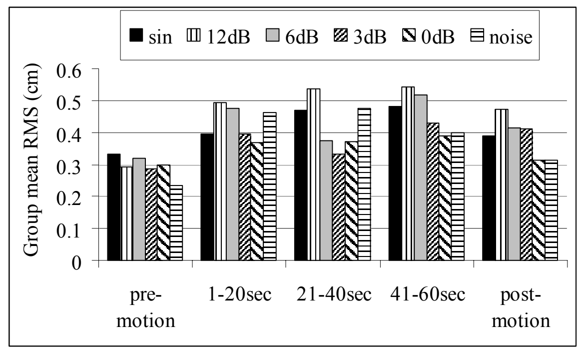

Figure 3: RMS values for AP head sway responses to each of the six tone-in-noise visual scenes. Head responses are representative of those for hip and COP as well. This plot summarizes data from 36 trials (6 subjects x 6 trials). RMS values are group means (n=6) in centimeters. Each 80 second trial was portioned into 5 intervals, as indicated on the x-axis. The pre- and post- intervals are 10 seconds long.

REFERENCES

Jacobson, J. et al. (2001). *Proceedings of the Virtual Reality Software & Technology Mtg.*

Kuo, A. et al. (1998). *Experimental Brain Research*. **122(2),** 185-95.

Loughlin, P. et al. (1996). *IEEE Trans. Rehab. Eng*. **4(4)**, 416-424.

Peterka R (2002). *J Neurophys,* **88**, 1097 1118.

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