THE ROLE OF CENTRAL AND PERIPHERAL VISION IN THE CONTROL OF UPRIGHT POSTURE DURING ANTERIOR-POSTERIOR OPTIC FLOW

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INTRODUCTION

Numerous studies over the past several decades have investigated how the integration of the visual, vestibular, and somatosensory systems contributes to the maintenance of postural stability. Experiments using various oscillating visual environments have shown a marked increase of sway amplitude in response to the stimulus (e.g., Lee and Lishman 1975; Lestienne et al. 1977). Several theories have been developed in an attempt to characterize the functional roles of central and peripheral vision in maintaining postural equilibrium (Bardy et al. 1999). However, it is not clear which theory best reflects the available data since many different methodologies have been used. This study seeks to better understand how central and peripheral vision influence postural sway.

METHODS

Twenty healthy subjects (mean age: 24 ± 3 years) who were naïve to the specific purposes of the experiment participated after providing informed consent. The experiment was a repeated measures design consisting of 3 main factors: field of view (FOV) of the moving stimulus, frequency of the moving stimulus, and surface support. Postural sway of the head and pelvis in the antero-posterior (AP) direction was acquired using the Polhemus Fastrak™ system. Center-of-pressure (COP) data were also recorded in the AP direction from a NeuroTest™ force platform, which could rotate about an axis collinear with the subject's ankles.

During each 90-second trial, subjects were surrounded by a contiguous front screen and two side screens, encompassing 180 degrees horizontal field of view (Figure 1). The images were displayed on the screens using three LCD projectors. The central portion of the stimulus was a black-and-white target pattern comprised of a black center circle (5° in radius) and five alternating rings (each 5° wide), giving the entire target a diameter of 60°. The height of the target was adjusted so that its center was aligned with the subject's eye height. The periphery of the stimulus was a black-and-white checkered pattern.

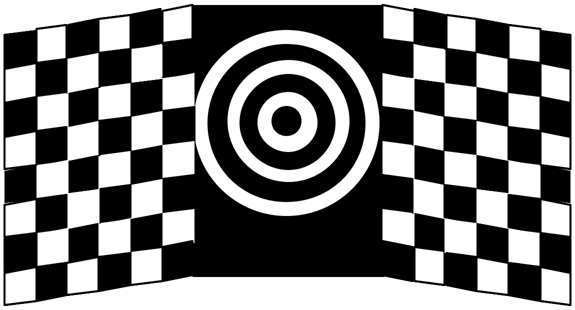

Figure 1: Unfolded schematic of the full visual stimulus. Side walls were folded around the subject to encompass the horizontal field of view.

The trials varied according to two independent visual parameters: (1) the frequency of sinusoidal visual oscillations (16-cm peak-to-peak amplitude) in the AP direction: 0.1 Hz and 0.25 Hz; and (2) the FOV of the stimulus: full, peripheral, and central. For the full FOV condition, both the central and the peripheral objects were present; for the peripheral FOV condition, only the side checkers were present; and for the central FOV, only the target was seen. Each subject observed all six visual stimuli during both fixed and sway-referenced surface conditions. (Sway-referencing was accomplished via the Neurotest to reduce somatosensory inputs from the ankle).

Data were sampled at 20 Hz. Root-Mean-Square (RMS) amplitudes of the AP head sway were calculated after the data were filtered with a 2nd-order Butterworth bandpass filter centered at the stimulus frequency (±0.05 Hz). Statistical analysis was performed using a repeated measures ANOVA to test for the effects of Frequency, FOV, and Surface condition ($\alpha = 0.05$).

RESULTS AND DISCUSSION

The RMS amplitude of head sway obtained from the experimental conditions is shown in Figure 2. For the fixed surface condition, the amplitude of sway was similar across visual conditions – except for a reduction in sway at 0.25 Hz when only the central target was presented. For the sway-referenced surface condition, again a reduction of sway is evident for the central FOV. Furthermore, the attenuation at 0.25 Hz is remarkable.

Repeated measures ANOVA revealed significant main effects of Surface condition ($p < 0.001$) and FOV ($p < 0.001$). The main effect of Frequency was not significant ($p = 0.06$), nor was the 3-way interaction. However, there were significant 2-way interactions between FOV*Frequency ($p = 0.001$), FOV*Surface ($p = 0.002$), and Frequency*Surface ($p = 0.02$). The FOV*Frequency and FOV*Surface interactions appear to be primarily related to the reduction in sway at 0.25 Hz when the central FOV was presented.

Thus, the data suggest that visual influences on posture are highly frequency dependent in the central field when somatosensory inputs are unreliable. However, the peripheral field appears to be influential along a broader frequency range when somatosensory cues are reduced. More testing at other frequencies is required to fully examine this effect.

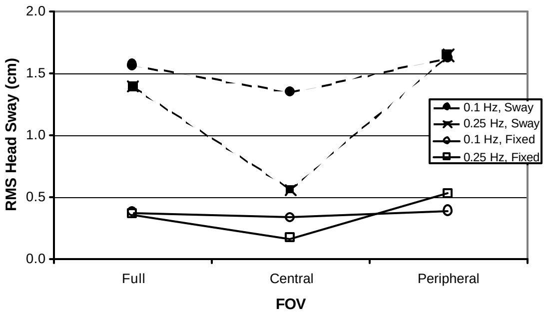

Figure 2: RMS head sway for each of the visual/surface conditions.

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