THE ROLE OF INITIAL CONDITIONS IN THE POSTURAL SWAY RESPONSE TO
GALVANIC VESTIBULAR STIMULATION

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INTRODUCTION

The galvanic (electrical) vestibular stimulus (GVS) elicits postural sway in human subjects during stance. The stimulus is created by applying current to electrodes overlying the skin of the mastoid processes behind the ears. The current creates a small-localized electric field that alters the resting potential of the vestibular nerve. If the anode is placed at one mastoid and the cathode at the other (binaural – bipolar configuration), postural sway will be elicited in the frontal plane towards the anode (Redfern, 1994). The sway response is typically quantified by measuring either the displacement of the head or the center of pressure (COP).

The postural sway response to GVS has been used for many years to study the role of the vestibular system in postural control. The potential applications of this technique in the clinic diagnosis of vestibular system dysfunction are many (Cass, 1996). Unfortunately, the large between-trial variability in the responses has necessitated the collection of a large number of trials and has subsequently precluded its widespread clinical use. One of the potential sources of variability in the response is the postural initial condition. The goal of this study was to determine the effect of the initial conditions, initial position (IP) and initial velocity (IV), on the postural sway responses measured at the head and the center of pressure (COP).

METHODS

The subjects were 10 normal healthy young adults ages 22 to 31 years with no known history of otological disease. The stimulus consisted of a binaural-bipolar pulse of amplitude 0.5 mA and duration 5 sec. The displacement of the head was recorded by a magnetic position tracking system (Flock of Birds, Ascension Technologies). The displacement of the COP was calculated from the forces and moments that were obtained from a force plate (Bertech Corporation model 4060A). Each trial consisted of a random duration pre-stimulus period of up to 60 seconds, the 5 seconds of stimulation, and then a 5-second post-stimulus period. Each of the stimuli was presented 15 times as three sets of five stimuli. A quiet stance trial of 30 seconds was recorded before each set to determine the baseline position and velocity.

The IP and IV of the head and the COP were normalized using the baseline position and velocity for each experimental set to allow averaging across sets and subjects. The IP of each segment was calculated as the mean position during the one-second period preceding stimulus onset. This value was divided by the standard deviation of its corresponding baseline to obtain a normalized IP. Similarly, the normalized IV was calculated as the mean velocity during the one-second preceding the onset of the stimulus divided by the standard deviation of the baseline velocity. The distributions of IP and IV were broken into three groups by percentile, negative = 0% - 33%, low = 34% -66%, and positive = 67% - 100%. Each trial was assigned to an IP group and to an IV group.

RESULTS AND DISCUSSION

The ensemble-averaged displacements of the head and the COP are shown in Figure 1. The anticipated response is a rapid deviation of both the head and the COP to the left following the onset of the stimulus and a rightward deviation back to center following the termination of the
stimulus. This response is seen in the displacement of the head at all three initial positions. However, it is apparent in this figure that the head displacement that is elicited by the stimulus (change in displacement during the trial) is much smaller than the displacements that occur spontaneously (the distance between the three curves before stimulus onset). The displacement response of the head following both positive and negative IV is larger than the responses elicited with zero IV.

Both the displacements of the head and the COP were parameterized by calculating the peak magnitude of the response during the stimulus period. A multi-factorial ANOVA was used to determine significant sources of variation in the peak magnitude. Both IP and IV were found to have significant effects on the peak magnitude of the response. A post-hoc analysis revealed that when a subject assumed an initial position in the direction of the anticipated response, the subsequent response was substantially decreased. Initial positions centered over the base of support and opposite the direction of the anticipated response permitted, but did not enhance, the subsequent response. The effect of increasing the initial velocity was to increase the magnitude of the response, regardless of the direction of the initial velocity.

The implications of these findings for the use of GVS in the clinical diagnosis of vestibular disorders are: (1) the initial position and velocity should be recorded. These quantities can then help guide the interpretation of the response. (2) The number of trials necessary to obtain consistent responses can be greatly reduced by eliminating the postural initial conditions as a source of variability.

Figure 1: Ensemble-averaged displacements of the head (a) and the COP (b). The period during the stimulus is shown in gray. Each curve shows the response following one set of initial conditions.

REFERENCES
