The Effect of Predictability of Stimulus on Visually-Induced-Motion-Sickness

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Background

- Through research and innovation engineers have produced better vehicles, boats, and planes that suppress the motion characteristics that make people motion sick (though not intentionally)
- While the virtual reality world expands, better technology (software/hardware) has produced more motion sickness
- The Experience of Motion Sickness
  Instability, Dizziness, Nausea, Fatigue (Sophite Syndrome) – just to name a few

Sensory Conflict Theory

- Probably the most well known and intuitive theory – has been around since the Ancient Greeks.
- Asserts that Motion sickness is produced when the brain receives information from different senses unsynchronized with each other (reporting different motion 'realities')
- While the Brain attempts to resolve this conflict, one can become motion sick (Reason, 1978; Oman, 1982)

Postural Instability Theory

- Despite it's intuitive appeal, Conflict Theory does not provide an objective measure of conflict, nor does it allow sickness to be predicted a priori
- PI Theory asserts Motion Sickness is not related to a sensory conflict, but instead a decreased ability to appropriately control one's postural motion (Riccio & Stoffregen, 1991)
- The longer one remains unstable – the more likely that sickness will occur
- Research has shown that postural motion can predict sickness (Stoffregen & Smart, 1998; Stoffregen, et al, 2000; Smart, Stoffregen, & Bardy, 2002).

Role of Behavior

- PI theory places emphasis on understanding behavior and how we control it
- Control is dependent on the pick up of relevant information as well as the appropriate coordination of actions (perception-action cycle; Gibson, 1979)
- The execution of action relies on the successful detection of the emerging features of the environment (Reed, 1996).
- The ability of the organism to exhibit this forward-looking, or prospective, characteristic is especially critical for postural control (Gibson and Pick, 2000).
- Consequently, in situations where the characteristics of the environment change in an unpredictable manner, prospective control of posture may be difficult.
- The predictability of the environment may also have important consequences with regards to adaptation.
- Kennedy, et. al. (1990) suggested that the lack of predictability of complex stimulus waveforms might contribute to the increased incidence of sickness.

Research questions & Hypotheses

- The current study is the first of four experiments examining the role of predictability of stimulus on Visually-induced-motion-sickness (VIMS).
- The expectation of the study was that there would be a low occurrence of motion sickness due the predictable nature of the stimulus.
- It was expected that the participants would achieve a stable control strategy either by following the stimulus or ignoring it completely.

Methods

Participants

- Sixteen undergraduate students (9 males, 7 females) ranging in age from 18 – 22 yrs.
- All participants had normal or corrected-to-normal vision and were in good health with no history of inner ear (vestibular) dysfunction or dizziness/falls
- Participants received class credit for their participation
- Participants were aware that there was a chance that they would become motion sick.

Materials

Motion Tracker: body movement was tracked using a magnetic tracking system (Flock of Birds, Ascension, Inc.) Four sensors were used (see Fig. 1). Motion was sampled at 40 Hz.

- Sensor I– Right Ankle
- Sensor II– Right Knee
- Sensor III– Sacrum (base of spine)
- Sensor IV– Head

Figure 1. Sensor setup

Stimulus

Starfield Simulation: A random dot 'starfield' which oscillated in the AP axis with a frequency of 0.25 Hz and an amplitude of 15 cm was employed for the control (60 sec) and experimental (600 sec) trials.

Projector: A Sharp PG-C30XU projector was used to present the stimuli, producing a image with an unobstructed visual angle of 29°(V) x 37°(H) – distance 2.76 m

See Figure 2 for screenshots of stimuli

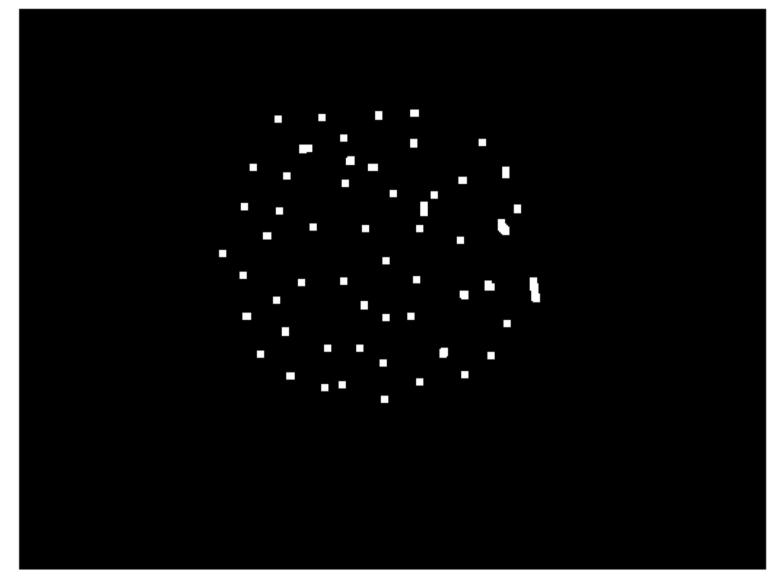


Figure 2. Screenshot of Stimulus

Procedure

- Participants were told the nature of the study and ask to fill out a consent form, demographics sheet, and a Simulator Sickness Questionnaire (SSQ, Kennedy & Lane, 1993)
- Participants were asked to perform two balance checks before beginning the experiment (these were repeated before participant was allowed to leave).
- Participants were standing and the sensors were placed on their body.
- Participants in each session were presented with three types of trials: 4 baseline (20 sec), 4 control (60 sec), and 4 experimental (600 sec).

Analysis

Data & Analyses:

- Motion data was collected in six axes of motion (AP, Lateral, Vertical, Roll, Pitch, & Yaw) for each sensor.
- Variability, velocity, and range of head movement was analyzed in each axis.
- A phase analysis was conducted on the
- Finally, we analyzed the SSQ to determine whether the simulation produced any symptoms of sickness.

Data & Analyses: SSQ

The SSQ scores were tested using a Kruskal-Wallis Chi-square test (Table 1).

Total:
The test was significant, X^2 (2) = 15.695, p = .000.
Interpretation: total scores were higher in the posttest than the pretest.

Nausea subscale:
The test was significant, X^2 (2) = 13.358, p = .001.
Interpretation: nausea scores were higher in the posttest than the pretest.

Oculomotor subscale:
The test was significant, X^2 (2) = 13.687, p = .001.
Interpretation: oculomotor scores were not higher in the posttest than the pretest.

Disorientation subscale:
The test was significant, X^2 (2) = 6.559, p = .038.
Interpretation: disorientation scores were higher in the posttest then the pretest.

General Interpretation - SSQ
- Two people reported being sick. However, the scores indicate that some participants had elevated symptoms that were not verbally reported to the experimenters.

	Nausea subscale	Oculomotor subscale	Disorientation subscale	Total
Pretest score	9.54	18.6	7.59	15.0
Posttest score	23.4	30.3	25.3	31.0

Table 1. SSQ Scores

Data & Analyses: Postural Motion

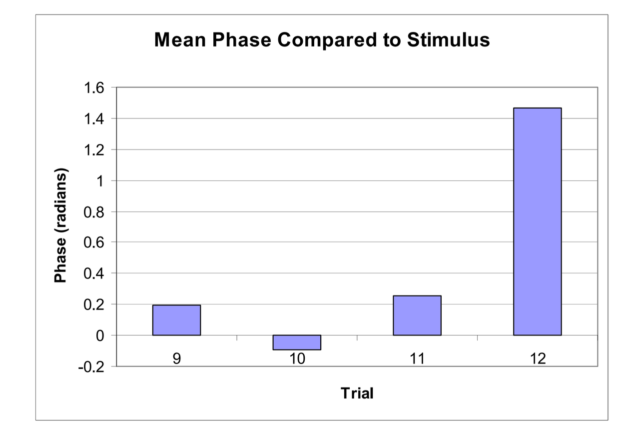
Control Trials

- The effect of vision (eyes open vs. eyes closed) for variability, velocity, and range of head movement for each axis of movement was examined (t-tests).
  Result: No significant differences were found.
- The effect of vision on the phase difference between the movement of the participant's head and the movement of the stimulus was also examined using the William's-Watson's test.
  Result: There was a significant difference (F(1,46) = 9.499, p <.01) between the phase of the participant and the stimulus when they had their eyes open versus when they had their eyes closed. With their eyes open, they were in phase with the stimulus, while with their eyes closed they were not in phase with the stimulus.
  Interpretation: The participants were being affected by the stimulus.

Experimental Trials

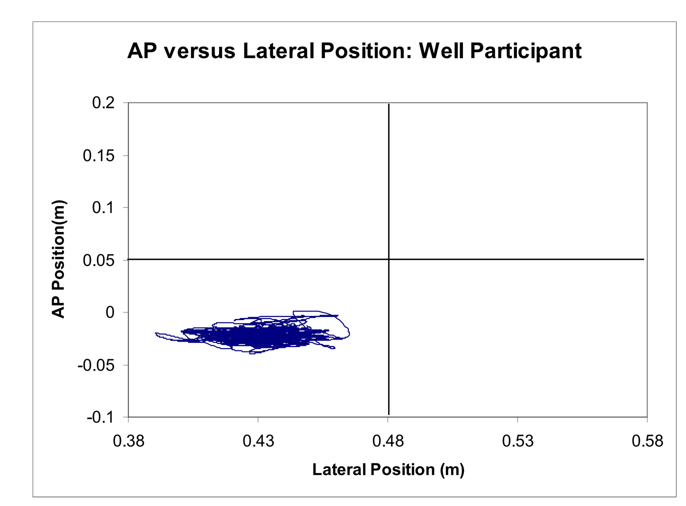
(Since only 2 of the 11 participants reported being sick, the analyses conducted for the control trials were not the same as for the experimental trials.)

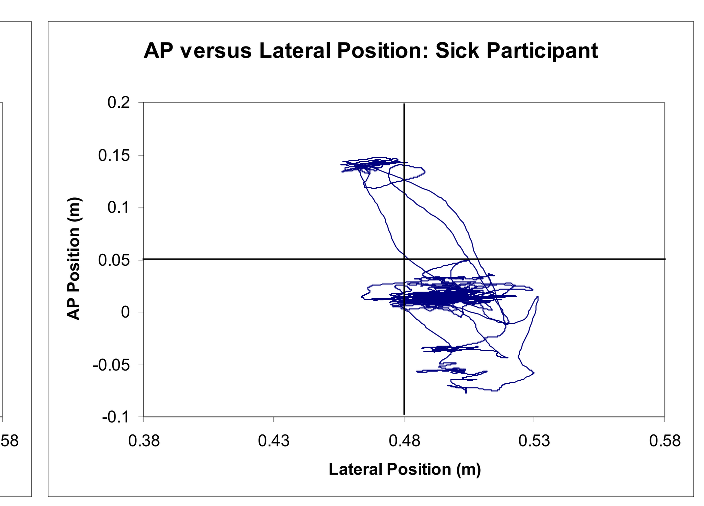
- The mean phase for each experimental trial was examined:



Interpretation: The data suggests that the participants remained relatively in phase with the stimulus for the first three experimental trials and then appeared to begin to ignore the stimulus by the fourth experimental trials.

Position-Position plots:





Interpretation: The sick participant was more unstable that the well participant.

Conclusions & Future Directions

- As expected, very few people became sick as a result of being exposed to the stimulus. The control trials indicated that the participants were in fact being affected by the stimulus, and the examination of the mean phases of the experimental trials indicated that the participants remained in phase with the stimulus or ignored it. This was also what was expected given the predictability of the stimulus being presented.
- It is interesting the note that the participants were in phase with the stimulus even though the experimenters did not tell the participants to try and move in phase with the stimulus.
- This experiment was the first of four examining the effect of predictability of stimulus on VIMS. The next three experiments will involve using the present stimulus with a Head Mounted Display (HMD), using a complex, sum of sines stimulus with a projector, and using a complex, sum of sines stimulus with a HMD.

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