Stop this crazy thing: The role of control in visually induced motion sickness

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Background

Prospective Control

According to the goal-regulation framework, one must be able to successfully assess and interact with one’s surrounding environment.

Three behaviors in turn rely on the ability to recognize the possibilities for action (affordances) that exist within a given context.

The success of control and its relevance to a particular situation depends on factors that lead to a successful interaction (Gibson, 1980; 1990; 2000).

The performance of prospective control is characterized by the ability to plan, monitor, and modify the expected result of an action.

When this is achieved the person is in a position to perform subsequent actions.

Internal (closed-loop) versus External (open-loop) Control

In meta-analysis studies, there is a large effect size favoring the control condition under open-loop conditions (Gibson, 1990).

This type of control can be characterized as closed-loop in nature (where the participants’ actions influence and are influenced by information from the world).

However, there are a number of situations where the relation between perception and action is open-loop (where the participants have no control over the environment).

In both cases the goal of the person is to interact successfully (i.e., in a manner that reduces the distance between the current and goal states) with the environment around them.

While errors of control in these situations are accomplished that differ as a function of the type of control (internal, closed-loop vs. external, open-loop).

Prospective control can come when an appropriate strategy is implemented by the person; one such problem in motion versus being the occurrence of motion sickness.

Motion Sickness

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.

Sensory-Conflict Theory

According to the conflict theory and intuitively – has been around since the Ancient Greeks.

While motion sickness is produced when the brain receives information from different senses uncorrelated with each other (reporting different motion realities).

Within the brain attempts to resolve this conflict, one can become motion sick (Palmer, 1978; Oman, 1982).

Postural Instability Theory

Despite its relative appeal, Conflict theory does not provide an objective measure of conflict, nor does it allow one to be predicted or prevented.

The sensory conflict is one that is not related to a sensory conflict, but instead a decreased ability to appropriately control one’s motion sickness (Roberts & Steffmen, 1991).

The former one is perhaps more understandable – the more likely that sickness will occur.

Research has shown that postural motion can predict sickness (Steffen, 1998; Steffen et al., 2000; 2002; 2003).

The relationship between the movement and subsequent analysis of sequenced postural motion while stimulating the vestibular system.

It is believed that disturbances in postural control that can be produced by virtual environments may lead to heightened sickness effects (Roberts & Steffmen, 1991) and that these effects will be more pronounced when the person is exposed to externally generated (open-loop) motion.

Methods

Participants

Fourteen undergraduate students ranging in age from 18 – 22 years.

All participants had normal or corrected-to-normal vision and were naive to experimental procedures.

No participant received class credit for their participation.

The 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 II). Four trackers were used (Figure 1). Motion was sampled at 40 Hz.

Stimulus

Game design and software: A Nintendo 56-bit video game, with standard controller, was used to generate the stimulus for all of the participants to be used in this study.

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, et al., 1993).

Participants were asked to perform two checks before beginning the experiment (these were repeated before participant was allowed to begin).

Participants sat on a stool, holding the game controller comfortably in their hands.

Participants in each session were presented with three types of trials: 1 baseline condition (post, 20 s), 5 control (pre, post, 20 s), and 6 experimental (200 sec).

Figure 1. Setup and screenshot of stimulus

Figure 2. Representative example of Displacement analysis.

Figure 3. Postural Motion

The following plots display representative examples of sick participants and well participants (Figures 2-5). There are two factors of executive: 1) AP head translation versus Lateral head translation (mn) and 2) Phase AP motion (mn) versus AP velocity (mn pxl).

Analysis & Results

SSQ

Pre-exposure: A Kruskal-Wallis (non-parametric) test revealed no significant differences between the pre-exposure scores on the Neausea, Disorientation, or Oscilomotor subscales, indicating that the pre-exposure scores for the sick participants did not differ from the well participants.

Post-exposure: A Kruskal-Wallis (non-parametric) test also revealed no significant differences between the post-exposure scores on the Neausea, Disorientation, or Oscilomotor subscales, indicating that the post-exposure scores for the sick participants did not differ from the well participants.

Postural Motion: Variability, Range, and Range of Motion

Data was collected in the form of 136 trials, which were analyzed to determine the range of motion.

Experiment: A main effect of condition was found in lateral variability, indicating that when participants were playing the game (active) they moved more than when they were watching the game (passive).

A control health questionnaire was found in lateral range, indicating that well participants had the same magnitude of excursion whether active or passive, while sick participants moved less while passive than active.

Postural Motion: Displacement Analysis

Displacement analysis is a type of fractal analysis that can be used to examine the similarity of measured data across time scales.

This analysis calculates the log of the variance (relative dispersion, RD) at multiple time scales and compares them to the log of the mean (slope of a linear regression) by determining the log-log relationship can be used to calculate the fractal dimension of a time series.

The value of D varies between 1 and 1.5, with values near 1 indicating uniformity over all time scales and values near 1.5 indicating randomized noise.

As the value of D increases, it indicates that the larger time scales do describe the data in a similar manner as the smaller time scales (Ding et al., 1994).

The analysis was conducted on the experimental trials only.

Lateral: There was a marginal main effect of condition, F(1, 36) = 3.35, p = .073. This trend was observed that the value of the displacement exponent was larger when a participant was sick then when they were well. (Figure 7)

Future research will include using a less stable posture than sitting (such as the use of a sit or standing), and to utilize alternative titles that necessitate control over the degree of freedom that the current task which was predominantly in the AP axis (for example a flight simulator).

References