GRAVEL Seed Grant Proposal

Cover Page

December 29, 2004

Title: **New capabilities in research on motion sickness in games and virtual environments**

PI: Thomas A. Stoffregen
Affiliation: School of Kinesiology
Position: Professor
Email: tas@umn.edu
Address: Cooke Hall, 1900 University Ave SE, 55455
Phone: 612-626-1056

Description of the project

Classically, motion sickness has been associated with transportation, but improvements in vehicle design have made sickness rare in most transportation systems (the space shuttle is a conspicuous exception). Despite this, there is renewed interest in the cause and prevention of motion sickness. This is due to frequent reports of motion sickness among users of simulation technology. Sickness is common in systems that depict motion of the user, such as flight and driving simulators, and many other virtual environment systems (Stanney et al., 1998; Stoffregen et al., 2000). The effectiveness of simulation and virtual environment systems, and their acceptance by users, can be severely limited if they produce motion sickness (Biocca, 1992; Stanney et al., 1998). This provides a strong practical motivation for understanding the malady.

Most virtual environments are consist of visual simulations, and so are considered to create *visually induced motion sickness* (e.g. Hettinger & Riccio, 1992). Visually induced motion sickness is known to exist in laboratory devices, such as a moving room (Lishman & Lee, 1973; Stoffregen, 1985; Smart et al., 2002; Stoffregen & Smart, 1998), in fixed base flight simulators (e.g., Stoffregen et al., 2000), and in head-mounted displays, or *HMD*s (Cobb, 1999; Cobb & Nichols, 1998; Draper et al., 2001). In general, there is a positive correlation between the technical sophistication of visual simulation and the incidence of motion sickness among users (Crowley, 1987; Kennedy & Fowlkes, 1992; McGuinness et al., 1981; Nickerson, 1992). Put simply, the better the system looks, the more likely it is to induce motion sickness. This correlation highlights the importance of behavioral research on the motion sickness in simulator systems: By itself, technological development is making the problem of motion sickness worse, not better. Technological development, *per se*, will not solve this problem. What is needed is behavioral science research on how people interact with simulator systems.

One area of rapid technological improvement is console video games, such as *Play Station*, and *Xbox*, in which players use a handheld controller (known as a *game pad*) to interact with a visually presented virtual world. Among designers there is great competitive pressure to maximize the subjective compellingness or involvement of users. These systems have exhibited rapid improvement in both software and hardware, with resulting improvement in the realism of player movement, game scenarios, and environments. These improvements raise the question of whether console video games may give rise to visually induced motion sickness. Motion sickness among players of console video games is widely discussed, but not well documented. Computer-based video games also have wider significance. Games play a large role in driving research and development in areas that previously had been confined to the engineering and computer science communities (Pagulayan, Keeker, Wixon, Romero, & Fuller, 2002). Games act as showcases for cutting-edge developments in both software and interactive hardware systems. The appearance of anecdotal reports of motion sickness among users of console video games is, thus, an ominous sign not only for the console game industry, but also for designers and users of virtual environments, in general. Ongoing research in our lab (Merhi & Stoffregen, 2004) has documented the reality of motion sickness among users of console video games. When playing commercially available games presented through a head-mounted display, the incidence of motion sickness among users (during a

50 minute play session) was 91% (11 out of 12 participants) while standing, and 42% while sitting. Sickness was also conspicuous in more typical game situations. In our most representative condition, an Xbox game was presented on a 25-inch video monitor with participants sitting at a comfortable viewing distance (36 inches): In this condition, the incidence of motion sickness was 42%.

The use of commercially available games allows our existing research to give an estimate of the incidence of motion sickness under realistic, representative conditions. A limitation of this method is that we cannot control the experimental stimulus and, as a result, we cannot do controlled experiments to uncover the causal factors that underlie motion sickness in virtual environments. In addition, results found when imagery is presented through an HMD cannot be assumed to generalize to other visual presentation technologies. In the proposed project, we will address these two limitations.

Our proposal. The purpose of the proposed project is to develop a new basis for conducting research relating postural sway and motion sickness to video games and virtual environments. We aim to create an animated graphical representation of the oscillatory motion that is used as a stimulus in my "basic" research. The animated graphic can be used as a stimulus for research on postural motion and motion sickness in different virtual environments. An MPEG or Quicktime file will be created, simulating the motion used in my basic research, having the same duration and motion parameters. That file can then be presented to experimental subjects through my existing HMD system (Visette Pro, Cybermind Interactive, Inc.). Separately, an existing video projector can be paired with a new rear-projection screen to create an additional type of virtual environment. The use of animation graphics presented via video projectors on rear-projection screens is common in research relating vision and stance and, of course, in many simulation and game applications. Thus, the extension to motion sickness research is plausible. Additional video files can be created with variations in the amplitude and frequency of oscillation of the virtual environment. These variations will permit us to test predictions made by the postural instability theory of motion sickness (Riccio & Stoffregen, 1991).

Description of the broader potential of the idea

Motion sickness is emerging as a propensity of almost any form of visual computer graphics that depict motion of the user ("first person" motion). Flight simulators, driving simulators, HMD-based applications, and now even desktop and console video games. Understanding the causes (and prevention) of motion sickness among users of console video games will aid in the development of an understanding of visually induced motion sickness, in general. This, in turn, can lead to design innovations that make it possible to 1) identify persons at risk for motion sickness with particular devices or applications, 2) provide warning, in realtime, that an individual currently is at risk of developing motion sickness, and 3) provide means of altering the parameters of games and virtual environments, in realtime, so as to prevent motion sickness (Stoffregen & Smart, 1998).

Idea development team

PI: Thomas A. Stoffregen. Team: Omar Merhi, Cedrick Bonnet (graduate students), Elise Faugloire (post-doctoral fellow). Mr. Merhi has extensive experience conducting research on motion sickness in Xbox games, and relating sickness to postural motion. Mr. Bonnet and Dr. Faugloire are both funded by my current NIH grant for "basic" research relating postural motion to motion sickness.

Budget

1. Day-Lite from EPA-Audio MN
56"x96"HD Fast Fold Kit (p/n-88624) $730.00

2. Software/programming to use the sum of sines software to directly generate computer graphic movies that we can manipulate. For use in HMD and with rear projection. $1750.

Total: $2480

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Signature page

Michael G. Wade, Head, School of Kinesiology

Signature: _____

Date: _____