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Driving Simulator Sickness Screening: Efficient and Effective New Protocol

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ABSTRACT
Driving simulators allow researchers to study situations that would otherwise be difficult or impossible to investigate. Simulator sickness can negatively affect these studies, make participants uncomfortable or ill, and waste the time of both participants and researchers. A new, faster, simulator sickness screening protocol has been developed, based on prior protocols. We describe an ongoing longitudinal quantitative assessment using an electronic version of the screening protocol to verify our initial experience with a paper version of high accuracy in excluding participants who would otherwise have to drop out of a driving study due to simulator sickness.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces And Presentation (e.g., HCI)**]: User Interfaces –graphical user interfaces (GUI), interaction styles (e.g., commands, menus, forms, direct manipulation), user-centered design; I.6.7 [**Simulation and Modeling**]: Simulation Support Systems

General Terms
Design, Experimentation, Human Factors.

Keywords
Simulator Sickness Screening, Driving.

1. INTRODUCTION

1.1 Simulator Sickness
Simulator sickness (SS) occurs for some people when they use a simulator. Symptoms of SS are similar to those of motion sickness (MS), and can include disorientation, dizziness, headache, dry mouth, and even drowsiness, vomiting, and nausea. Fortunately, SS tends to occur less frequently than MS, and with less severe physical and mental symptoms [1, 2, 3]. Nevertheless, SS can still have negative effects on an experiment, and confound data through reductions in psychomotor control and participant dropout [2]. And, of course, due to the potential negative effects of SS on participants it is vital to try to decrease the frequency and severity of symptoms, so as not to harm participants [1].

1.2 Screening for Simulator Sickness
Several attributes of driving scenarios (e.g., curves, steady braking, intersections, time driving, and speed of the simulated vehicle) and physical simulator or environment-based factors (e.g., room temperature) have been found to impact SS [1,5,6,7,8,9]. While researchers have attempted to modify these factors to address SS, others have attempted measuring SS (and then dealing with it later during data analysis) to tackle the issue. To this end multiple SS measurement scales have been developed over the years. Some of the original SS measurement scales were based on measurements of purely *motion*-related symptoms; examples include the Pensacola Diagnostic Index (PDI) and the Pensacola Motion Sickness Questionnaire (MSQ) [10,11]. Problems with these measurements for driving simulator use included their reliance on a single score of determining SS, and not being designed specifically for SS. This led researchers to create new multidimensional scales such as the SS questionnaire (SSQ), and MS assessment questionnaire (MSAQ) [3,11].

Unfortunately, addressing environmental factors and measuring any residual SS was not sufficient. Researchers determined they needed to screen individuals before participating in a driving study. However, by giving pre-screening surveys based on previous SS or MS, researchers screened out some who would not get SS in the study. Other researchers saw the possibility of using an SS survey, plus the completion of a scenario in the simulator, to screen for SS [1,7]. For that reason, Brooks et al. adapted the MSAQ and reported more than 90% accuracy in their screening protocol [1].

The present study is an attempt to measure the effectiveness of the new Georgia Tech SS screening protocol. The procedure and supporting software tools, were developed for the Georgia Tech School of Psychology's mid-fidelity, fixed base driving simulator, and is discussed in greater technical detail in [4]. The ongoing research aims to determine how well the screening protocol identifies participants who may experience SS during a study, before they begin. This is done to avoid harming subjects through experiencing strong reactions of SS after longer exposure, and in order to save time of the researchers and participants. The earlier version of the SS screening method worked very well after its development, but the current electronic version was created to speed up the process and to allow for ease of quantitative longitudinal evaluation of its effectiveness.

2. METHOD

2.1 Participants
The sample for this research is a combination of participants from separate driving research studies in a large research university in the southeastern United States. Participants are required to have a valid driver's license and normal or corrected-to-normal vision.

2.2 Apparatus

2.2.1 Driving Simulator
The driving simulator used in this study is a quarter-cab National Advanced Driving Simulator (NADS) MiniSim. The simulator's visuals are displayed on three 42" plasma monitors and an LCD

screen for the instrument panel. The simulator conveys sound through a 2.1 audio system and participants use an adjustable steering wheel, gas and brake pedals, and gear shifter for input.

2.2.2 Screening Protocol

The current screening protocol including the apparatus and the procedure will be briefly described below, however for more detail see Gable and Walker [4]. The GT SS screening survey used here is a modified version of the version of MSAQ used in Brooks et al. [1]. In this version, participants use a touch screen unit fixed in the simulator to answer 17 questions about their current state of feeling. The survey uses a scale from 0 to 10 where 0 is "not at all" and 10 is "severely" regarding the dimensions of: sick to stomach, faint-like, annoyed/irritated, sweaty, queasy, lightheaded, drowsy, clammy/cold sweat, disoriented, tired/fatigued, nauseated, hot/warm, dizzy, like I am spinning, if I may vomit, uneasy, and floating. They then complete a short (2 minute) drive through a purpose-built scenario using the NADS scenario development tool. The driving scenario's brevity keeps the acclimation drive short, while still introducing drivers to maneuvers that may trigger feelings of SS. Finally, drivers complete the survey a second time, after the drive.

The computer then calculates any changes in physical feeling between the two drives, and recommends whether the driver should continue with the study or not. If at any time during the acclimation drive (or later in the study) participants report any feelings of sickness, the simulation is stopped.

2.3 Procedure

Over the course of a number of months all participants who partake in simulator studies using the School of Psychology simulator have gone, and will continue to go, through this new electronic version of the protocol before the start of the experiment. When a participant is removed from a study due to the screening or partway through a study due to SS these data are recorded in the database. At the end of the study period all of the screening files output by the program will be analyzed to quantitatively assess the effectiveness of this screening technique.

3. CURRENT AND EXPECTED RESULTS

Since this screening process was adapted in part from Brooks et al. who found accuracy of above 90% in their screening process it is to be expected that this screening should show a similar validity [1]. Accordingly it is predicted that only 10% or less of participants that make it through the protocol without being recommended to stop will exhibit SS symptoms and have to stop the study part way through. Although not enough screenings were done with the paper version of the screening for a statistical analysis of the magnitude desired we did not have any participants drop out of studies due to simulator sickness post screening.

It is our expectation that the current, more formal, and quantitative evaluation will echo our initial and anecdotal findings. It should also be said that, even though screening times and ease of assessment are not reported in other studies, this new protocol is expected to be faster and more efficient than other screenings due to our use of in-vehicle assessment, a computerized survey using a touchscreen interface, automated scoring, integrated data archiving for longitudinal evaluation, and the short (2 min) acclimation driving scenario.

4. DISCUSSION

The newly developed GT simulator sickness protocol is already showing great promise. If, after this more formal evaluation, the screening protocol is indeed found to be as effective and efficient as it seems, it will enhance the driving research performed at Georgia Tech. Of course, our intentions in developing such a tool is to share it widely with other MiniSim users, and help adapt it for use in other simulators. While the current investigation is focused on young populations, research has found relationships between age and prevalence of SS [1,8]. Thus, we plan to systematically expand the range of participants screened, including older adults and those who have various special challenges (e.g., drivers with traumatic brain injury, low vision).

5. ACKNOWLEDGMENTS

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