CAN SEA BANDS® BE USED TO MITIGATE SIMULATOR SICKNESS?

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Summary: A North American tier-one automotive supplier (TOAS) conducted a study in 2002 using a vehicle driving simulator to study simulator sickness. The goals of the study were twofold: (a) determine a screening process to identify those individuals who should be excluded from future simulator studies due to their susceptibility to simulator sickness and (b) explore a mitigation technique to lessen the severity of simulator sickness symptoms using the FDA-approved Sea Bands® acupressure wrist bands. The study revealed that prior experience with motion sickness is not necessarily a good predictor of who will become sick in a simulator, but one's own perception of susceptibility to motion and simulator sicknesses may be a reliable predictor. It also revealed that the acupressure wrist bands may be an effective method for managing simulator sickness among older participants.

INTRODUCTION

Simulator sickness is an important issue, which needs close attention and management for any studies being conducted in a simulated or virtual environment (VE). Many studies have been carried out with the goal of discovering a method or methods to mitigate simulator sickness. In addition, many studies have been carried out with the goal of discovering a reliable method of predicting which individuals will have greater susceptibility to simulator sickness than others. The ability to predict this reliably would allow researchers to exclude from studies those individuals for whom mitigation techniques might be ineffective.

In 2002, a North American tier-one automotive supplier (TOAS) conducted a study using a dynamic driving simulator to explore a prediction technique for simulator sickness and a potential treatment to mitigate its effects. The experimenters employed a variation of the Motion Sickness History Questionnaire (MSHQ) developed by McGee (1998) and the Simulator Sickness Questionnaire (SSQ) developed by Kennedy et al. (1999) to gather subjective data from the participants on their experiences and perceptions of motion sickness, and on sickness symptoms after immersion in the driving simulator's VE. Given recent evidence that acupressure may have a significant impact on treating the side-effects of nausea in chemotherapy patients and sufferers of seasickness (Hu, et al., 1995; FDA Approves Sea-Band Acupressure Wristband, 2004; Barsoum, Perry & Fraser, 1990; Roscoe, 2003), the researchers chose to investigate the effectiveness of the acupressure wrist bands known as Sea Bands® to treat the effects of simulator sickness. This study indicates that the use of Sea Bands® may significantly reduce the severity of some simulator sickness symptoms. The study also indicates that prior episodes of motion sickness may not be a reliable or accurate predictor of who will experience simulator sickness. However, the study also suggests that an individual's own perception of their susceptibility to simulator sickness may be an effective predictor of who will experience it and to what level of severity.

PROCEDURE

Each participant was scheduled for an initial appointment of thirty minutes that included a five-minute acclimation drive. Before the acclimation drive, participants were asked to complete the MSHQ. After completing the acclimation drive, participants were scheduled for the actual study drive. They were asked to return to the simulator exactly 48 hours from the initial appointment. For the study drive, participants were instructed to drive either 15 minutes or 60 minutes, depending on which level had been assigned to them by the experimenters. It is important to note that the participants were not told which duration would be assigned to them until they returned for the study drive. After completing the study drive, the participants were asked to complete the SSQ. Upon leaving the simulator facility, each participant was given another SSQ and was asked to complete it approximately four hours after completing the study drive.

Apparatus

The driving simulator used in this study contains a quarter-cab vehicle mounted atop a six-degree-of-freedom platform facing three projection screens. At the time of study, the cab was that of a Mercury Mountaineer. The projection screens provide a 180-degree front field of vision and simulated rear and side view mirrors. The virtual driving environment included urban, rural, and highway segments. A driver can choose to either remain on-road or venture off-road.

Method

The experimental design was a randomized factorial design with drive time, age and wearing of Sea Bands® as the main independent variables. This experimental design was intended for a between-subjects study. Both the length of the study drives and wearing of Sea Bands® had two levels: 15- or 60-minute drive; wearing or not wearing the band. For this study, the experimenters investigated three age levels: 18 – 25 years; 38 – 45 years; 55 years or older. The experimental design can be seen in Table 1.

Table 1. Experimental Design

	Age Group 1 = younger 2 = middle 3 = older	**Presence of Sea Bands®**					
		Band			No Band		
Drive Time (minutes)	15	1	2	3	1	2	3
	60	1	2	3	1	2	3

The dependent variables were Total Sickness (TS) scores obtained immediately after the study drives and Total Sickness scores obtained 4 hours after the study drives were completed (TS4). Both the TS and TS4 scores were derived from SSQs given to the participants. The SSQ sub-category scores were also included in the experimental design as dependent variables. The complete list of dependent variables is listed in Table 2.

Table 2. Dependent Variables

Response measures taken from the SSQ immediately following study drive	**Response measures taken from the SSQ four hours following study drive**
• Total Sickness score (TS)	• Total Sickness score (TS4)
• Nausea sub-category score (N)	• Nausea sub-category score (N4)
• Oculormotor sub-category score (O)	• Oculormotor sub-category score (O4)
• Disorientation sub-category score (D)	• Disorientation sub-category score (D4)

Task

The acclimation drive was a scripted, constrained drive aimed to allow the participant to become accustomed to simulator driving and to help prevent simulator sickness, as suggested by Kennedy (Kennedy, Stanney & Dunlap, 2000). The drive started in an urban location containing several obstacles around which the user was forced to navigate. No adverse weather conditions or exceptional road conditions (e.g., oil slick, construction) were induced, and the user was asked to keep his speed under 40 mph. In the event of a crash, the drive was simply restarted.

The study drives were unscripted and unconstrained. For those participants who wore the acupressure Sea Bands®, the experimenter explained the purpose of the bands, and assisted the participant in properly placing the bands on the wrists before the study drive began. The participants were told they could drive wherever they wished within the 50-square-mile virtual world, and at whatever speed they deemed appropriate. The study drives started at a pre-defined highway rest stop location. Other traffic in the virtual world was present. No adverse weather conditions or exceptional road conditions were induced. In the event of a crash, the experimenter simply restarted the drive at the same highway rest stop. Participants were instructed on how to stop the experiment if they felt too much sickness to continue. The researchers followed a protocol to help participants manage any sickness symptoms and bring the participant back to a state of well-being.

Results

Factor Effects on Simulator Sickness during Immersion. Table 3 shows the ANOVA results for the SSQ scores TS, N, O, and D. An analysis of variance (ANOVA) of the total sickness scores indicates that the length of the study drive alone has a significant impact on the TS score reported by participants ($F = 11.72$, $p < 0.001$). Although neither age nor presence of a Sea Bands® alone appear to significantly impact TS as main effects, the interaction of the age group and the presence of the wrist band does have a significant impact on TS scores ($F = 5.29$, $p < 0.008$). The participants in the older age category (over 55 years) who wore the Sea Bands® reported lower TS values than those who did not wear the bands. A Tukey pairwise comparison of the three age groups indicated that it is indeed the older age group who reported significantly lower scores while wearing the bands, in comparison to the two other age groups, which were not significantly different from one another.

Table 3. ANOVA Results for TS, N, O, and D

		TS		N		O		D	
Source	**df**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**
Age Group (A)	2	1.31	0.278	3.75	0.030	0.32	0.725	0.39	0.682
Intended Drive Time (D)	1	11.72	0.001	9.75	0.003	14.26	0.000	5.96	0.018
Band (B)	1	2.72	0.105	1.18	0.283	4.00	0.051	2.21	0.143
AxB	2	5.29	0.008	5.13	0.009	3.95	0.025	3.69	0.032
AxD	2	1.27	0.290	1.78	0.179	0.95	0.395	0.56	0.577
BxD	1	0.68	0.412	0.78	0.380	0.44	0.511	0.42	0.518
AxBxD	2	2.74	0.074	2.87	0.066	3.85	0.028	1.27	0.291
Error	51								
Total	62								

The results from the sub-category scores ANOVA indicate only the Oculormotor (O) sub-score is somewhat significantly impacted by presence of the Sea Bands® ($F = 4.00$, $p < 0.51$), whereas the Nausea sub-score was the only one significantly impacted by age ($F = 3.75$, $p < 0.030$). Intended drive time significantly impacted all three sub-category scores (N: $F = 9.75$, $p < 0.003$, O: $F = 14.26$, $p < 0.000$, D: $F = 5.96$, $p < 0.018$). This was also true of the interaction between age and presence of Sea Bands® (N: $F = 5.13$, $p < 0.009$, O: $F = 3.95$, $p < 0.025$, D: $F = 3.69$, $p < 0.032$). The three-way interaction of age, band and intended drive time significantly impacted the O sub-scores ($F = 3.85$, $p < 0.028$).

Factor Effects on Simulator Sickness Post-Immersion. Table 4 shows the ANOVA results for the SSQ scores TS4, N4, O4, and D4. The analysis indicates that age has a significant impact on the TS4 score reported by participants ($F = 3.51$, $p < 0.037$). This is also true of the N4 and O4 scores (N4: $F = 4.05$, $p < 0.023$, O4: $F = 4.42$, $p < 0.017$). The ANOVA analysis also appears to indicate significance of the three way interaction of all three factors on TS4 and N4 (TS 4: $F = 3.19$, $p < 0.049$, N4: $F = 3.28$, $p < 0.046$). However, this result should be regarded with caution, especially given that no other main factor and none of the two-way interactions appear to significantly impact TS4.

Predicting Simulator Sickness Susceptibility from Motion Sickness History. Three questions were chosen from the MSHQ for regression analysis against scores from the SSQs. These questions asked participants to rate how frequently they experienced motion sickness in an automobile (MHQ Car), how susceptible to motion sickness they perceive themselves (MHQ Suscept), and how likely they think that they would experience simulator sickness in a study where 50% of the participants became sick (MHQ Chance). The responses were rated on Likert scales, such that the lower the score, the more sickness the participant experienced in the past or perceived themselves to be susceptible to motion and simulator sickness. These three particular questions were selected from the MSHQ given the significance that McGee found with these questions in his study on sickness in virtual environments (McGee, 1998).

Table 4. ANOVA for TS4, N4, O4, and D4

		TS4		N4		O4		D4	
Source	**df**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**	**F**	**Prob (p<0.05)**
Age Group (A)	2	3.51	0.037	4.05	0.023	4.42	0.017	1.56	0.221
Intended Drive Time (D)	1	1.95	0.169	1.81	0.184	0.49	0.488	3.38	0.072
Band (B)	1	0.19	0.668	0.02	0.879	0.76	0.387	0.00	0.950
AxB	2	0.78	0.462	0.58	0.566	0.36	0.697	1.82	0.172
AxD	2	2.36	0.104	2.54	0.089	1.22	0.302	2.37	0.104
BxD	1	0.56	0.459	0.83	0.368	0.77	0.384	0.05	0.819
AxBxD	2	3.19	0.049	3.28	0.046	2.85	0.067	1.88	0.164
Error	51								
Total	62								

The statistical analysis indicates that the question concerning a participant's previous history with car sickness is not a significant factor in the regression model. However, the questions dealing with the participant's own perception of their susceptibility to and chances of experiencing simulator sickness do play a significant role in the model.

The regression equation is TS = 103 - 9.14 MHQ Chance - 16.3 MHQ Suscept + 5.72 MHQ Car
S = 28.77 R-Sq = 24.8% R-Sq(adj) = 21.0%

Table 5. Regression Analysis with MHQ Questions

Predictor	Coef	SE Coef	T	P
Constant	103.28	28.55	3.62	0.001
MHQ Chance	-9.144	5.108	-1.79	0.079
MHQ Susc	-16.297	5.532	-2.95	0.005
MHQ Car	5.720	6.530	0.88	0.385

DISCUSSION

Predictions

Predicting Simulator Sickness Susceptibility based on Motion Sickness History. We found that previous experiences with motion sickness on its own might not be able to accurately, reliably and consistently predict who will experience simulator sickness. This may be due to the differences between the stimuli that evoke motion sickness versus those which evoke simulator sickness. Thus, the actual experiences of motion sickness due either to vestibular over stimulation or postural instability do not necessarily carry over to the virtual environment. However, this study found that the level to which participants perceive themselves to be susceptible to simulator sickness has a significantly strong correlation to higher SSQ scores.

Simulator Sickness Mitigation with Sea Bands®. Our results indicate that older participants overall reported higher TS scores. The data analysis also indicates that older participants who wore Sea Bands® reported significantly lower TS scores when compared to older participants who did not wear Sea Bands®. However, the sub-score that was most highly affected by the presence of Sea Bands® was Oculormotor Discomfort (O), not Nausea (N), as would be expected given the assertion that Sea Bands® effectively mitigate motion sickness symptoms and nausea. This suggests a possible placebo effect of the Sea Bands® in terms of its effectiveness in mitigating simulator sickness symptoms and their severity.

The analysis did indicate that the longer participants drove in the simulator, the higher their TS scores were, regardless of age. This supports other research which indicates that adaptation in simulator sickness does not necessarily come from prolonged uninterrupted exposure (Witmer, B. & Lampton). However, it is important to concede that, since the study drives were unscripted, length of time spent driving the simulator alone may not be the only significant factor in the severity of simulator sickness reported. It is possible that those individuals who drove longer also drove courses involving more curves and jerky movements, producing more severe levels of sickness symptoms.

Recommendations

Any future study of simulator sickness mitigation techniques should thoroughly examine the role that gender may play in both the efficacy the Sea Bands® mitigation method and the ability to reliably and accurately predict who may develop severe simulator sickness symptoms. In the case of this study, the experimenters were not able to include gender as one of the main factors, due to the overall lack of female participants in the TOAS employee pool at all three age levels. In addition, reliance on gender alone as a predictive factor may not prove to be accurate for simulator sickness. Evidence exists to suggest that females indeed tend to report motion sickness more frequently and with higher severity than males (Reason & Brand, 1975). This is despite the fact that there is no physiological difference in the way in which males and females experience the stimuli which produces motion sickness.

Further study in the use of acupressure wrist bands to manage simulator sickness is strongly recommended, given the outcome of this study and given the inconclusive evidence on when such a technique works and why. A study investigating the use of acupressure wrist bands on chemotherapy patients indicated a significant reduction in reported nausea and vomiting in the patients who wore the bands. Also, studies involving sea sickness and vection-induced motion sickness both claim that the P6 bands significantly reduced the severity of motion sickness symptoms and even had an objectively observable effect on physiological responses, like gastric myoelectric activity (Hu, et al., 1995). However, another study which paired the P6 wrist bands with the motion sickness drug, hyoscine, showed no more significant reduction in motion sickness symptoms as a control group, who received both a placebo drug with a placebo band (Bruce, et al., 1990).

Finally, any future studies on simulator sickness should aim to control the route and conditions of the study drives. The study drives in the TOAS study were unscripted. This may have been a significant source of variation in the reported simulator sickness symptoms, especially considering other research into simulator sickness that suggests that a driving environment which induces the participant to make quick and jerky head and body movements could lead to severe sickness symptoms, regardless of how long the drive is (Witmer & Lampton).

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