SIMULATOR SICKNESS IN TANK DRIVER TRAINERS

Robert B. Raisler
Simulation, Training and Instrumentation Command (STRICOM)

Donald R. Lampton
Army Research Institute for the Behavioral and Social Sciences
Orlando, FL

ABSTRACT

The M1 Tank Driver Trainer (TDT) is an excellent example of how computer-based simulators can provide training that is less expensive, safer, and more flexible than training conducted with operational equipment. The TDT uses computer-generated imagery and a six-degree of freedom motion base to provide training for the driver of the M1 Abrams main battle tank. The TDT facility at Ft. Knox , KY can provide training for 18 drivers simultaneously, all running independent scenarios. The TDT will save millions of dollars over its life cycle. Unfortunately, as with many simulators that depict movement, simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

At the request of the U.S. Army Training and Doctrine Command (TRADOC), the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) conducted research to determine if TDT training was being affected by simulator sickness and, if so, ways to either prevent or alleviate it. ARI collected baseline data on the incidence and severity of symptoms reported by a One Station Unit Training company during their first and some subsequent training sessions. Symptoms were measured using questionnaires, interviews, and a test of balance. For comparison purposes, symptoms were measured following field driving sessions with actual M1 tanks. In addition, Instructor/Operators (I/Os) were interviewed concerning their observations on simulator sickness, and I/O records were tabulated for companies that had previously trained with the simulator. This paper provides background information on simulator sickness, discusses the incidence and severity of symptoms experienced by TDT trainees, changes in symptoms over time, recommendations for alleviating simulator sickness, and how the Ft. Knox User benefitted from those recommendations. In addition, suggestions are presented for simulator sickness research to guide the future design and use of Virtual Environments for training.

ABOUT THE AUTHORS

Mr. Raisler is a Project Director in PM Close Combat Training Systems at the Simulation, Training and Instrumentation Command (STRICOM) in Orlando, FL. Robert is Project Director on five Tank Driver Trainer (TDT) projects; the US M1 TDT, the US M1A2 TDT, the Saudi M1A2 TDT, the Kuwait M1A2 TDT and the Egypt M1A1 TDT. His background includes seven years as a Dept. Of Navy Senior Project Engineer supporting Army trainer and simulator development and fielding before spending the last three years supervising the TDT programs. Prior to working with the Government, Mr. Raisler held engineering positions with NCR, Martin Marietta, and Honeywell Aerospace. He holds a Bachelor of Science degree in Physics and a Bachelor of Science degree in Electrical Engineering.

Co-author: Donald R. Lampton

Mr. Lampton is a Research Psychologist with the Army Research Institute for the Behavioral and Social Sciences (ARI). For the last eight years he has been with the ARI Simulator Systems Research Unit in Orlando, FL. He is currently conducting research on training applications of Virtual Reality technology. He is co-developer of the Virtual Environment Performance Assessment Battery (VEPAB). Mr. Lampton has an M. A. in Experimental Psychology from the University of Louisville.

SIMULATOR SICKNESS IN TANK DRIVER TRAINERS

Robert B. Raisler
Simulation, Training and Instrumentation Command (STRICOM)

Donald R. Lampton
Army Research Institute for the Behavioral and Social Sciences
Orlando, FL

INTRODUCTION

Simulator sickness is a potential problem with any simulator that portrays self-movement to the trainee, whether that movement is flying in a fixed or rotary wing aircraft, driving or riding in a vehicle, or moving on foot. Simulator sickness refers to unwanted side effects and aftereffects that may result from using simulators such as flight or driving training simulators. When simulator sickness occurs, common symptoms include nausea, dizziness, and headache or eyestrain. Simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

The M1 Tank Driver

The TDT is a computer-based simulator designed to provide training for the driver of the M1 Abrams main battle tank. The TDT includes a completely enclosed driver compartment which replicates the interior of the M1 tank's driver compartment. The TDT driver compartment is situated upon a motion platform capable of producing six degrees of motion (pitch, roll, yaw, heave, surge, and sway). Three display screens present computer-generated imagery simulating the view from the driver's hatch. Both closed hatch, in which the driver peers through protective vision blocks, and open hatch views can be simulated. The system can play 20 different and distinct sounds, including the turbine engine, turret traversing, tracks, indirect fire, main gun firing, and others.

The TDT provides an excellent example of how computer-driven training simulators can provide training that is less expensive, safer, and more flexible than training on operational equipment. Operation of an actual tank costs about $92 per mile. In contrast, the TDT costs less than $6 per mile including Instructor/Operator (I/O) salary, contractual maintenance, and electricity. The TDT will save millions of dollars over its life cycle.

Training in the TDT is safer than training in an actual tank. In a tank, unlike in the cockpit of many aircraft or the front seat of most ground vehicles, the "driving instructor", the Tank Commander (TC), can not sit next to the trainee or take control of the vehicle in an emergency. The driver is physically separated from the other crew members. The TC can not see or touch the driver and communication is limited to speaking through the Combat Vehicle Crewman intercom.

Because of the power and mass of a tank, a driving error can lead to injury or death of the tank crew members or bystanders, and damage to the tank and other equipment or facilities. For example, during driving training the TC stands on a support within the turret so that part of his upper body is above a hatch. If the trainee drives erratically, brakes abruptly or hits an obstacle for example, the TC can be thrown out of the tank.

The TDT can represent a wide range of driving conditions. It can simulate driving at day or night, and under different weather conditions such as haze, fog, ice, or snow. A wide variety of terrain can be depicted such as urban areas, rolling hills, desert, or mountainous areas. In addition, the TDT can represent other moving vehicles with which the trainee must react or coordinate movement.

Tank driving training involves much more than learning to safely and efficiently move from point A to point B. Although the complexity of tank driving in combat is beyond the scope of this paper, we believe it is safe to assume that a well-trained driver contributes significantly to the offensive and defensive capabilities of a tank in actual combat.

The TDT provides a cost-effective, safe, and flexible complement to training with actual tanks. Unfortunately, as with many simulators that depict movement, simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

Simulator Sickness

Simulator sickness is a potential problem with any simulator that portrays self-movement to the trainee. Simulator sickness refers to unwanted side effects and aftereffects resulting from use of simulators such as flight simulators or driver training simulators. These effects are similar to, but not limited to, motion sickness symptoms such as nausea and dizziness. In addition, visual discomfort, such as eye strain or difficulty in focusing, is a dimension of simulator sickness. Simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees (Kennedy, Hettinger, & Lilienthal, 1988).

Simulator sickness may degrade training effectiveness despite the absence of severe symptoms such as vomiting. Discomfort in the simulator may distract the trainee. Simulator sickness may lead to negative transfer of training in that the trainees may adopt behaviors that mitigate sickness in the simulator, but will be detrimental if transferred to the actual vehicle. Aftereffects involving the sense of balance, such as postural disequilibrium (ataxia), or flashbacks could possibly impair the trainees' ability to drive safely after leaving the simulator. The training value of a simulator is reduced if simulator sickness forces a decrease in the frequency or duration of use of the simulator.

Discomfort resulting from use of a simulator should not necessarily be interpreted as simulator sickness (Kennedy et al., 1987). Simulator sickness refers to sickness or discomfort resulting from performing a task in a simulator for which performance of the same task in the real-world does not produce similar sickness or discomfort.

Simulator sickness is thought to result, at least in part, because simulated movement results in a conflict between the human body's mechanical systems and visual systems for sensing movement. Treisman (1977) proposed that a change or conflict in the relationships between the senses may be interpreted by the body as an indication that toxins (poison) have been ingested. Therefore, nausea reaching the stage of vomiting would have survival value by removing the toxins. According to this explanation, simulator sickness is an unfortunate result of the inappropriate activation of this nausea response.

Kolasinski (1995) identified dozens of factors that previous research has indicated are involved in simulator sickness. Those especially relevant to training with the TDT are: experience with the simulator; and illness, sleep loss, and emotional stress. Previous research, mostly involving flight simulators, indicates that, all other things being equal, a trainee is most susceptible to simulator sickness during the first session with a simulator. For most trainees, simulator sickness declines during subsequent sessions. Other research has indicated that illness, sleep loss, and emotional stress may increase susceptibility to simulator sickness. Note that the characteristics of the simulator itself are only part of the simulator sickness picture. The characteristics of the tasks being simulated and the characteristics of the trainees are also critical determinants of simulator sickness.

Questionnaires and symptom checklists are the usual means of measuring simulator sickness because there are many different symptoms of simulator sickness; measuring just one sign or symptom would not be sensitive (Kennedy & Fowlkes, 1992). A commonly used questionnaire to measure simulator sickness in flight simulators is the Simulator Sickness Questionnaire (SSQ) which was developed by the ESSEX Corporation (Kennedy, Lane, Berbaum, & Lilienthal, 1993).

The SSQ symptom list consists of 16 symptoms which are rated by the trainee on a 4-point scale (0=none, 1=slight, 2=moderate, 3=severe). These ratings form the basis for three subscale scores - Nausea, Oculomotor Discomfort, Disorientation - as well as a Total Severity score. Examples of the symptoms are: general discomfort, sweating, nausea, difficulty concentrating, fatigue, headache, eyestrain, dizziness, and vertigo.

The Total Severity score uses all of the symptoms and reflects the overall extent of symptom severity and is therefore the best index of whether or not a sickness problem exists. The SSQ subscale scores can provide diagnostic information as to the specific nature of the resulting sickness. Kennedy et al. (1993)

have published baseline SSQ data obtained from Navy Flight simulators which can serve as a comparison for other systems.

In addition to the symptoms identified by the SSQ, loss of sense of balance, also called postural disequilibrium or ataxia, is another potential aftereffect of simulator exposure. Thomley, Kennedy, and Bittner (1986) suggested that ataxia may be caused by a disruption in balance and coordination resulting from the visual and vestibular adaptation to conflicting cues occurring during simulator exposure. Although sophisticated devices are being developed to measure ataxia, current research into simulator sickness often uses something similar to the "road sobriety test" administered by traffic officers.

Published recommendations for alleviating simulator sickness have for the most part been directed towards flight simulators. Kennedy et al., (1988) listed several guidelines or rules for reducing simulator sickness which have been implemented at Navy flight training sites. They pointed out that persons most susceptible to simulator sickness are those new to the simulator, and that adaptation of the individual is one of the strongest and most potent fixes for simulator sickness.

McCauley and Sharkey (1992) proposed that simulator sickness is inevitable for a substantial proportion of users of flight and driver simulators. They stated that engineering fixes to simulator sickness are already in the region of diminishing returns. However, they noted that although even excellent engineering may not prevent sickness, poor engineering or calibration will contribute to simulator sickness. Casali (1986) noted that most driving simulators, both those with and without motion platforms, have had problems with simulator sickness.

As a final background note we quote from the beginning and end of an article by Lerman et al., (1992) which described their investigation of sickness among trainees using an Israeli tank driving simulator:

> A military tank driving simulator has recently been introduced as a training aid for tank drivers in the Israel Defense Forces. Reports of nausea and vomiting among the first users of the simulator launched our investigation of the possible existence of a motion sickness-like syndrome among simulator drivers. (p. 610)
>
> Given the vast application potential of tank simulators and the large investments they entail, it is incumbent upon simulator users, designers, and researchers to recognize, address, and solve the simulator sickness problem. (p. 614)

SIMULATOR SICKNESS IN THE TDT

Based on his observations during a visit to the M1 Tank Driver Trainer (TDT) facility at Fort Knox, the Assistant Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command (ADCS-T TRADOC), requested the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) to determine if TDT training was being affected by simulator sickness and, if so, ways to either prevent or alleviate it. ARI's research to address this question is presented in greater detail in Lampton, Kraemer, Kolasinski, and Knerr (1995), and is summarized below.

Purpose. The critical questions addressed by this research were: What are the incidence, severity, and dimensions of symptoms of simulator sickness (if any) resulting from training with the TDT? How do these symptoms compare with those produced by driving the actual M1 tank? Does the pattern of simulator sickness change with repeated use of the TDT? and, Can those individuals most susceptible to simulator sickness be identified prior to their use of the simulator ?

Research approach. A multi-faceted approach was used to measure simulator sickness in the TDT: An OSUT company of TDT trainees was administered background information questionnaires, modified SSQs, interviews, and tests of postural stability following training sessions on the TDT and actual M1 tanks. I/O records of simulator sickness were examined for six companies that had previously trained with the TDT. TDT I/Os were interviewed on various aspects of simulator sickness. A “test-drive” of the TDT was conducted. TDT engineering documents were examined for factors such as the specifications of maximum allowable asynchrony between visual display and motion platform operations.

Research design

The central element of the research design was the measurement of simulator sickness in one company of trainees during their first TDT session and then again after their first M1 field session. Comparison of these data would determine if TDT training was resulting in symptoms which did not occur with training in the actual M1. The interval (almost two months) between the first TDT session and the first M1 field session provided the opportunity to examine changes in simulator sickness over time.

The SSQ was the primary data collection instrument. Questions were added to address claustrophobia and to differentiate between warm sweating (normal sweating induced by body heat) and cold sweating (stress-induced sweating). The SSQ was pilot-tested and modified to make sure that the wording was appropriate for TDT trainees.

To take into account that some trainees may already have symptoms before they use the training device, some trainees were given the SSQ both before and after TDT training. The concern was not just that some pretraining problem might be misinterpreted as simulator sickness, but also that the pretraining problems may increase susceptibility to simulator sickness. A conceivable problem with this approach is that seeing the list of symptoms beforehand may sensitize the trainee to those symptoms or in some other way lead to exaggerated reporting of simulator sickness. Therefore, of the trainees who completed the SSQ, half were given the SSQ both before and after training in the TDT, the other half only completed the SSQ after exiting the TDT.

In addition to the SSQ, some trainees were interviewed to assess simulator sickness. Use of open-ended interview questions had the potential to identify symptoms, or unanticipated problems, of simulator sickness not dealt with by the SSQ. In addition, use of interviews avoided the concerns that seeing the list of symptoms on the SSQ might somehow result in an overestimation of the incidence or severity of simulator sickness. The interview began with the question "How do you feel"? asked in a neutral tone of voice by the interviewer. Regardless of the trainee's response, the interviewer then proceeded with a series of increasingly focused questions addressing the occurrence, severity, and time course of onset of symptoms.

The SSQ and the interview involve subjective measures of simulator sickness; both depend on the trainee to report symptoms that can not always be independently confirmed by the researcher. In contrast, a test of balance is an objective measure. The balance test required the trainees to stand on one foot, with eyes closed and their hands crisscrossed over their chest, and to maintain this posture for as long as possible up to a maximum of 30 seconds.

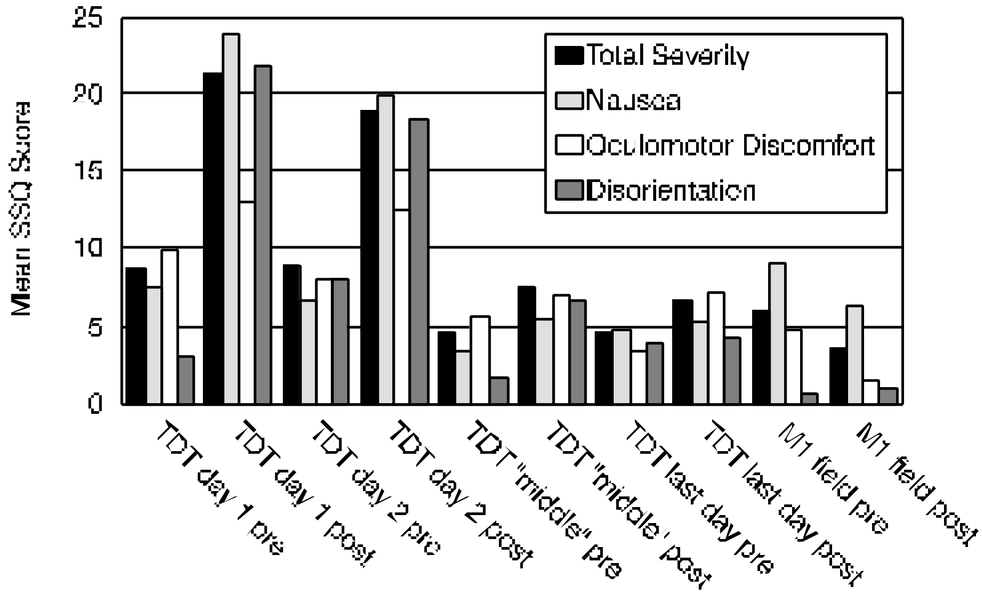
Data were collected on all the company trainees for their first TDT session, and on some of the trainees on several subsequent TDT sessions and their first driving session with actual M1 tanks. The subsequent TDT sessions were the second session, a "middle" session that corresponded roughly to the half-way point of the Program of Instruction, and the last TDT training session. The number of sessions of TDT training varied across individual trainees, thus the labels "middle" and "last".

Results

Figure 1 shows the average SSQ Total Severity score and the three subscale scores for the trainees' first, second, "middle", and last sessions on the TDT, and the first session of driving the actual M1 in the field.

Analyses of Variance (ANOVAs) revealed that for the TDT sessions, the Post-session SSQ Total Severity (TS) scores were significantly greater than the Pre-session scores. For two of the subscales, Nausea and Disorientation, the Post-session scores were also significantly greater than the Pre-session scores. (An alpha level of .05 was used for all of these statistical tests.)

Most trainees reported little or no discomfort during their first training session with the TDT. About 15% of the trainees interviewed responded that simulator sickness interfered



note: “pre” questionnaire administered before TDT training session

Figure 1. Mean SSQ Total Severity and subscale scores across TDT and M1 training sessions.

with their training, for example, exercises were suspended or terminated. Symptoms related to nausea were more prevalent than either eyestrain or dizziness. Approximately 6% of the trainees reported vomiting. Almost all of the trainees, even those who reported simulator sickness, stated that they enjoyed the TDT training sessions. The few trainees who rated themselves as susceptible to motion sickness prior to their first use of the TDT were more likely to report simulator sickness than those who did not rate themselves as susceptible. However, some trainees who rated themselves as "not at all" susceptible nonetheless reported simulator sickness. Subsequent training sessions resulted in significantly less simulator sickness than the first. Driving the actual M1 tank did not produce symptoms of simulator sickness.

I/O records of seven OSUT companies that had completed training on the TDT indicated that about 27% of the trainees experience discomfort, to the extent that it merited recording, at least once during the entire TDT POI. The I/O records indicated that the incidence of simulator sickness varied greatly across scenarios; five of the 22 scenarios accounted for about 80% of the incidence of simulator sickness. The five scenarios with the highest sickness rates were chronologically the 1st through 4th and the 6th scenarios presented to the trainees. Because the scenarios were almost always presented in the same order, it could not be determined if these five scenarios have characteristics that are more likely to produce sickness than the other scenarios, if simulator sickness declines as a function of the number of sessions a trainee has in the TDT, or a combination of these or other factors. Several of the most nauseagenic scenarios involved a computer-generated "ground guide" who has since been reprogrammed extensively.

Table 1 provides a comparison of our results with that of an Israeli study (Lerman et. al, 1992) of simulator sickness. (This is an admittedly rough comparison in that the method of the Israeli study differed from the TDT study.) For five of six comparable symptoms, the M1 TDT incidence is better or no worse than the Israeli tank driving trainer. Only nausea is worse with the M1 TDT.

Table 1

Comparison of Simulator Sickness for Two Tank Driving Simulators

	Trainees reporting the symptoms (%)							
	Driver Trainer				Tank			
	Any Severity		Moderate to High Severity		Any Severity		Moderate to High Severity	
Symptoms	TDT	ISIM	TDT	ISIM	M1	ITNK	M1	ITNK
Sweating	45.9	50.0	19.7	32.1	33.3	70.0	12.8	40.1
Dizziness	15.3	39.3	3.4	21.4	2.6	10.0	0.0	6.7
Nausea	35.5	29.6	16.1	11.1	5.1	20.0	0.0	3.3
Confusion	8.4	22.2	1.7	7.4	2.6	13.3	0.0	0.0
Drowsiness	27.8	35.7	1.6	13.3	2.6	40.0	0.0	13.3
Increased Salivation	5.0	14.3	0.0	3.5	0.0	6.7	0.0	0.0

TDT = M1 TDT ISIM = Israeli Driver Trainer M1 = M1 tank ITNK = Israeli tank

Test Driving the TDT

Three ARI researchers test-drove the TDT at the developing contractor's facility. The researchers concluded that there were no obvious errors in the design or construction of the TDT. Motion and visuals seemed to be well synchronized. Perusal of the technical specifications of the TDT indicated that the specifications were well within simulation industry standards for factors such as asynchrony of visual and motion cues. ARI researchers did not attempt to verify that the TDT is functioning within those specifications.

Discussion

Simulator Sickness Questionnaires administered to trainees, interviews of trainees and I/Os, and I/O records of simulator sickness all indicate the same pattern: although the majority of TDT trainees report few or no symptoms of simulator sickness, some trainees experience significant levels of discomfort during TDT training. The discomfort is significant in both the statistical sense and the sense that training is compromised.

Clearly, TDT training produced simulator sickness in some trainees. The SSQ Total Severity scores derived after the initial TDT training are significantly higher than the before-training scores and are significantly higher than the after scores for the initial M1 driving session. In interviews, about 20% of the trainees indicated that they were not feeling well following their first TDT session, and about 14% indicated that the discomfort was severe enough to interfere with training. I/O records indicate that about 25% of the trainees experience discomfort, to the extent that it merits recording, at least once during the entire TDT POI. Both questionnaire and interview data indicated that problems related to nausea were more prevalent than problems related to vision or the sense of balance. For the initial TDT training session, about 6% of the trainees who were administered the SSQ indicated that they experienced nausea severe enough to result in vomiting.

In regard to the findings of the incidence and severity of simulator sickness during the initial TDT training session several points can be made: Most trainees reported little or no discomfort from training with the TDT. Almost all trainees, even the ones reporting simulator sickness, stated that they enjoy training with the TDT. In general, the individuals most susceptible to simulator sickness can be identified by simple means before TDT training. There was no evidence that training with the TDT resulted in changes in postural stability.

The symptoms, incidence, and severity of simulator sickness observed with the TDT appeared no worse than those reported for a roughly comparable Israeli tank driver trainer. (Anecdotal reports indicate that simulator sickness on the Israeli tank driver trainer is considered an "opportunity" to practice driving under adverse conditions). Given the nature of the tasks to be trained (driving over rough terrain, for example) some simulator sickness should be expected. There is no indication that the TDT has any unique problems of simulator sickness in comparison with other training simulators.

SSQ, I/O interviews, and inspection of I/O records indicate that simulator sickness decreases subsequent to the initial TDT session. Several factors may be related to the decrease in simulator sickness across sessions. The trainees may perceptually adapt to the TDT visual and movement displays. They may learn to avoid actions, certain head movements for example, that produce simulator sickness. In addition, it may be that the scenarios encountered later in the POI may be less nauseagenic. For whatever reason, simulator sickness declines significantly across training sessions with the TDT.

There are three likely reasons that some individuals experience simulator sickness in the TDT. First, any driver trainer can produce simulator sickness. Drosdol and Panik (1985) concluded that for driving simulators, however complex, the vehicle model can only approximate the dynamic behavior of the real vehicle due to the restricted movement range. Most simulators are limited in that they must be physically anchored in the real world, and can move at most only a few feet in any direction. Motion in any direction can be sustained for only a brief time. The motion system must therefore use a variety of "tricks," such as using tilt to substitute for sustained forward (horizontal) acceleration, and "sub-threshold" return of the simulator to its neutral or resting position. Motion in the simulator cannot be exactly the same as that in the actual vehicle. This inconsistency between the visual and motion cues may form part of the basis for the simulator sickness. A variety of other individual factors (e.g., susceptibility to motion sickness), simulator characteristics (visual-motion lag, field of view), and task characteristics (e.g., type of movement required) may affect the severity of the problem, but the root cause is inherent in the nature of the simulators themselves.

Second, the TDT has a very powerful motion platform which is capable of producing "classic" motion sickness. Even if the visual and motion cues could be synchronized perfectly, or the visual display was turned off completely, driving over some terrain at certain speeds will produce movement patterns which will result in motion sickness in some trainees.

Third, anecdotal reports indicate that the TDT visual display will produce simulator sickness symptoms related to eyestrain if the trainee stares at one of the three terrain displays. Most trainees can and do avoid eyestrain by shifting their focus from display to display and to the gauges and controls in the interior of the driver's compartment mock-up.

Several points can be made about the methodology of measuring simulator sickness. During the course of the data collection, trainees with pronounced pallor (extreme or abnormal paleness) were observed and occasionally trainees were observed vomiting into plastic motion sickness bags immediately upon exiting the TDT cab. Of the hundreds of SSQs and interviews administered in only one case were there doubts about the veracity of the responses given by a trainee. During subsequent questioning that trainee stated that he had been confused about the rating scale. Those SSQ responses were not used in the analyses.

Clearly, valuable information was gained by presenting the SSQ before training. For example, it was determined that when the trainees arrive at the TDT many of them are tired and sleepy, factors which increase susceptibility to simulator sickness. In addition, some of the trainees are already "sick", due to colds or flu.

I/O records of simulator sickness proved valuable in several ways. Records of simulator sickness provide the user with a quantitative benchmark. They also provide a baseline by which the OSUT company under observation can be compared. That is, is the reported number of incidents of simulator sickness for the company the same or different from previous OSUT companies that trained on the TDT? Lastly, by providing a means to identify the most problematic training scenarios, I/O records enable the user to take a closer look at those scenarios and implement appropriate actions to help reduce or alleviate the simulator sickness problem.

Recommendations for alleviating simulator sickness in the TDT

Based on the findings presented above, ARI presented several recommendations to the CDR, 1st Armor Training Brigade. (See Lampton et. al, 1995, for a complete list of the recommendations, rationales for the recommendations, and references to relevant previous research).

Examples of these recommendations are:

Consider using the free play session to "inoculate" the trainee against simulator sickness: make the first session brief and avoid elements that tend to produce sickness.

Avoid prolonged driving on slalom courses.

For the five scenarios with the highest incidence of simulator sickness consider: replacement, modification, modification of how the scenarios are used, or presentation later in the POI when trainees are less likely to experience simulator sickness.

Decrease stressors affecting trainees on their first TDT training session.

The Rationale for this last recommendation: For field training it is to be expected, and sometimes wanted, that trainees will be fatigued or otherwise stressed during training. However, stress may be uniquely counterproductive during the first session on the TDT. In addition to lack of sleep, the trainees are under additional stress in that they hear rumors that the TDT will make them vomit.

When a trainee becomes ill he should be instructed to avoid watching the monitor at the I/O station. In addition, until recovered, the trainee should not be required to drive any (real-world) vehicle.

Trainees (and I/Os) should not be punished (or rewarded) for reporting simulator sickness.

FUTURE RESEARCH

At least three additional lines of research warrant consideration. One involves the role of motion platforms in simulator sickness. One justification of the cost of having a motion platform is to reduce simulator sickness. However, "turn off the motion until the trainee feels better" is an approach to combating sickness.

Regan and Ramsey (1994) found that administration of an anti-motion sickness medication reduced simulator sickness in virtual reality. However, effects on performance would be one of several factors that would have to be considered .

A third involves manipulation of the width of the field of view of the visual displays. A narrower field of view might be expected to produce less simulator sickness, but perhaps also reduce training realism and effectiveness .

SUMMARY AND CONCLUSIONS

The symptoms, incidence, and severity of simulator sickness observed with the TDT appeared no worse than those reported in a roughly comparable study of an Israeli tank driver trainer. Given the nature of the tasks to be trained (driving over rough terrain, for example) some simulator sickness should be expected. However, simulator sickness does degrade training effectiveness for some trainees. In addition, the threat of simulator sickness increases the workload of the I/Os and training program managers.

Simulator sickness is part of the "cost of doing business" in using flight and driver training simulators. A plan for management of simulator sickness should be a part of any training program which involves simulators which depict self-motion of the trainee.

REFERENCES

Casali, J. G. (1986). Vehicular simulation-induced sickness, Volume I: An Overview. IEOR Technical Report No. 8501. (NTSC TR 86-012). Orlando, FL: Naval Training Systems Center.

Drosdol, J. & Panik, F. (1985). The Daimler-Benz Driving Simulator: A tool for vehicle development. SAE Technical Paper Series 850334. Warrendale, PA.

Kennedy, R. S., Berbaum, K. S., Lilienthal, M. G., Dunlap, W. P., Mulligan, B. E., & Funaro, J. F. (1987). Guidelines for alleviation of simulator sickness symptomatology (NAVTRASYSCEN TR 87-007). Orlando, Florida: Naval Training Systems Center.

Kennedy, R. S. & Fowlkes, J. E. (1992). Simulator sickness is polygenic and polysymptomatic: Implications for research. International Journal of Aviation Psychology, 2(1), 23-38.

Kennedy, R. S., Hettinger, L. J., & Lilienthal, M. G. (1988). Simulator sickness. In G.H. Crampton (Ed.), Motion and space sickness, Chapter 15, 317-341. Boca Raton, FL: CRC Press.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). A simulator sickness questionnaire (SSQ): A new method for quantifying simulator sickness. International Journal of Aviation Psychology, 3(3) 203-220.

Kolasinski, E. M. (1995). Simulator sickness in virtual environments. (ARI Technical Report 1027). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lampton, D. R., Kraemer, R. E., Kolasinski, E. M., & Knerr, B. W. (1995). An investigation of simulator sickness in a tank driver trainer. (ARI Technical Report 1684). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lerman, Y., Sadovsky, G., Goldberg, E., Kedem, R., Peritz, E. & Pines, A. (1992). Motion sickness-like syndrome among tank simulator drivers. Israel Journal of Medical Science ol. 28. 8-9, August-September.

McCauley, M. E. & Sharkey, T. J. (1992). Cybersickness: Perception of self-motion in virtual environments. Presence, 1(3), 311-318.

Regan, E. C. & Ramsey, A. D. (1994). Some side-effects of immersion virtual reality: An investigation into the effectiveness of Hyoscine Hydrobromide in reducing nausea induced during immersion. (Report 94R025). Army Personnel Research Establishment.

Thomley, K. E., Kennedy, R. S., & Bittner, A. C. (1986). Development of postural equilibrium tests for examining environmental effects. Perceptual and Motor Skills, 63, 555-564.

Treisman, M. (1977). Motion sickness: An evolutionary hypothesis. Science, 197, 493-495.