Perceived Motion Sickness and Targeting Performance

Joakim Dahlman, Staffan Nählinder, Torbjörn Falkmer

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Phone: +46 13 37 80 00
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Abstract

With the purpose of studying targeting performance under the influence of motion sickness, in relation to self reported perceived motion sickness, a quasi-experimental repeated before- and after study was performed. The targeting performances of 22 basic training conscript soldiers with limited experience of riding the PBV 401 combat vehicle were examined after repeatedly being transported in it. Their perceived motion sickness was rated according to subjective scales before and after two exposures to transportation. Performance was measured using automatic targeting detectors and by military instructors. The confirmed hypothesis was that perceived motion sickness would lead to impaired targeting performance. A varimax rotated factor analysis divided the subjective scales' rated parameters into three representative factors, in which the second correlated significantly with targeting performance, indicating a relation between impaired targeting performance and perceived motion sickness symptoms. The two baseline measurements also correlated with the significant factor, indicating that performance between the repeated measurements was also affected negatively. The study supports the idea that motion sickness and its effect on performance should be studied by using actual performance measurements as a compliment to subjective ratings.

Keywords

Motion sickness, Performance, targeting performance

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Sammanfattning

I syfte att studera skjutprestation under påverkan av upplevd rörelsesjuka, med hjälp av subjektiva skattningar genomfördes en fältstudie med upprepad mätning. Skjutprestationen hos 22 värnpliktiga soldater, med begränsad erfarenhet av PBV 401 studerades efter två köromgångar i varierad terräng. Den upplevda rörelsesjukan skattades genom självskattningsformulär efter båda transporter. Prestation mättes med hjälp av en aukustisk registrering vid skjutbanan och med hjälp av instruktörer på plats. Hypotesen bekräftades genom att upplevd rörelsesjuka gav upphov till förämrad prestationsförmåga. En Varimax faktor analys delade in de skattade parametrarna i tre faktorer, där den andra korrelerade signifikant med skjutprestation och visade därmed på ett samband mellan försämrad skjutprestation och upplevda symptom. De två baseline skjutningarna korrelerade likaså med faktor två, och visade på att prestationsförmågan också försämrades mellan de två transport och skjuttillfällena. Studien bekräftar behovet av att studera röreslsesjuka och dess påverkan på prestationsförmågan med hjälp av objektiva prestationsmått som ett komplement till subjektiva självskattningar.

Nyckelord

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Perceived motion sickness and how it affects targeting performance

Joakim Dahlman[1], Staffan Nählinder[1], Torbjörn Falkmer[2]

[1] Swedish Defence Research Agency, Man-System Interaction. P.O. Box 1165, SE-581 11 Linköping.

[2] Rehabilitation Medicine, Department of Neuroscience and Locomotion, INR, Faculty of Health Sciences, Linköping University, Sweden

Abstract

With the purpose of studying targeting performance under the influence of motion sickness, in relation to self reported perceived motion sickness, a quasi-experimental repeated before- and after study was performed. The targeting performances of 22 basic training conscript soldiers with limited experience of riding the PBV 401 combat vehicle were examined after repeatedly being transported in it. Their perceived motion sickness was rated according to subjective scales before and after two exposures to transportation. Performance was measured using automatic targeting detectors and by military instructors. The confirmed hypothesis was that perceived motion sickness would lead to impaired targeting performance. A varimax rotated factor analysis divided the subjective scales' rated parameters into three representative factors, in which the second correlated significantly with targeting performance, indicating a relation between impaired targeting performance and perceived motion sickness symptoms. The two baseline measurements also correlated with the significant factor, indicating that performance between the repeated measurements was also affected negatively. The study supports the idea that motion sickness and its effect on performance should be studied by using actual performance measurements as a compliment to subjective ratings.

1. Introduction

This study was performed in order to examine new methods to study motion sickness and its effect on combat vehicle personnel in their naturalistic environment. Combat vehicle PBV 401 personnel in rifle units are exposed to motions without the ability to maintain visual contact with the outside environment. Conscripts being transported in this vehicle can sometimes be exposed to motions for several hours and at the same time preparing or performing tasks inside the moving vehicle. When disembarked, the team is supposed to get organized quickly, and rapidly open fire at the enemy. Hence, it is important that the team is not experiencing disorientation or under the influence of motion sickness when disembarking. However, it is obvious that there may be a risk for motion sickness among the conscripts with a possible impact on targeting performance. If early stages of perceived motion sickness could be reported by the conscripts, then this phenomenon could possibly be diminished. This study thus postulates a relation between perceived and increased motion sickness, due to motion exposure, and impaired targeting performance.

1.1 Background

For as long as people have been exposed to motion, the occurrence of motion sickness has affected personal well being (Morton, 1947). However, perceiving motion sickness does not require exposure to actual motion. It is sufficient to acquire a sensation of motion sensed by the vestibular system,

the eyes or the body to induce motion sickness. This means that a maintained posture initially requires information from vestibular sensory channels, vision and proprioceptive information, and this is normally performed on a subconscious level. If any of these stimuli are contradictive, a sensory conflict occurs (Reason & Brand, 1975, Förstberg, 2000).

Benson (1988) describes the sensory conflict theory as a conflict between or within these sensory systems and the expectations of the subject. This conflict can be expected to be present for personnel riding in armoured vehicles and other environments that are sealed off from the outside world.

Symptoms of motion sickness are of both physiological and psychological kinds. The symptoms vary from perceived disorientation or disturbed vestibulo-occular or spinal reflexes to physiological symptoms such as pallor, increased salivation, nausea and vomiting. Finally, we find the so called sopite syndrome which includes mood changes and sleep which can occur as a single symptom without signs of nausea (see e.g.: Lawson & Mead, 1998, Magnusson & Örnhagen, 1994). These symptoms obviously disturb when trying to function and they also affect performance, e.g. targeting performance (Cowings, et.al. 1999).

Motion sickness in armoured vehicles is not reported to be a significant problem in the Swedish army, although it does occur frequently and affects individuals and the team in different ways, depending on the severity of the

symptoms (Magnusson & Örnhagen, 1994). However, research in similar vehicle environments shows that appearance of motion sickness symptoms occur and affect task performance (Cowings, et al. 1999). The difficulty is often to discriminate between the causes of the decreased performance, i.e. if it is due to the motion itself or to the occurrence of motion sickness (Rolnick & Gordon, 1991). A study by Abrams et al. (1971) supports this by reporting that motions themselves did not seem to affect performance, but the occurrence of motion sickness perceived by subjects from the U.S. Navy caused a decrease in performance.

In a study by Cowings et al. (1999), performance was studied under various military transportation settings, using ratings and a cognitive task battery along with a physiological monitoring unit. The transportation vehicle in this study is similar to the ones used by the Swedish armed forces and keeps the soldiers out of visual contact with the outside environment. The results indicated that crew performance was significantly impaired during the moving conditions, as well as compared to the baseline measurements performed before and after motion exposure.

Previous studies regarding effects from transportation on performance in general show that the cause of impaired performance can be difficult to identify (Beck & Pierce, 1998) and therefore needs to be detected by using psycho-physiological measurements (Cowings, et al. 1986) combined with subjective ratings. Since subjects exposed to motion vary in susceptibility to

motion sickness, it is important to gain in-depth knowledge regarding the initial physiological processes that causes motion sickness. However, combining psycho-physiological measurements with subjective ratings usually means dealing with expectancy and anticipation of symptoms (Cowings, Toscano, DeRoshia & Tauso, 2001), which creates problems and adds further importance to the selection and categorization process of the susceptibility of motion sickness symptoms. Since the occurrence of motion sickness is very individual and stimulus-dependent effects on one subject can trigger symptoms in subjects not previously affected (Williamson, Thomas & Stern, 2004; Cowings, Naifeh & Toscano, 1990).

Considering that motion sickness symptoms derives from a mismatch between what we perceive with, for example, our eyes and what we sense with our vestibular system together with expectancy, one realises that there are many factors affecting the body and, furthermore, that in order to study performance under the influence of motion, it should to be studied under naturalistic situations, i.e. in its real context. It should also be noted that another major contributor to perceived motion sickness is anticipation, due to its transmittable ability to affect others. Recreating all these influencing factors outside the real world environment, for example in simulators or in an experimental setting, is difficult and especially since many of the factors affects subconsciously (Rolnick & Gordon, 1991, Hawton & Mack, 1997).

Regarding the two approaches, naturalistic vs. simulated context, it could be noted that motion sickness has for many years been studied within the transport community (De Graaf et al., 1998, Colwell, 2000, Morrison et al. 1991, Ritmiller et al., 1998, Losa & Ristori, 2002, Previc, 2001, Förstberg, 2000), but a considerable effort has also been done studying motion sickness in simulators (Stoffegen et al., 2000, Crowley, 1987). Since the use of virtual environments has expanded over the recent years within training and education problems with virtual reality (VR) related motion sickness has evolved, creating problems known as vection that can be explained as the illusion of self motion and occurs when performing stationary work in a moving environment (Howarth, 2003). The increased use of simulators has however not given birth to the problem with vection, but is common when placed still in a moving environment (i.e. optokinetic stimulation).

The above mentioned facts led us to conclude that in order to study how motion sickness might influence targeting performance for dismounted conscript soldiers after being transported in combat vehicles; it needed to be studied in a real world environmental context, using the tentative hypothesis that perceived motion sickness will lead to impaired targeting performance.

1.2 Aim of the study

The aim was to study targeting performance, both actual and rated, after transportation in a closed vehicle under the possible influence of motion sickness, in relation to self reported perceived motion sickness.

2. Methods

2.1 Subjects

The subjects were 22 male conscript soldiers from the Swedish armed forces. They were all doing their military service. The mean age was 19.2 years (SD. 0.43). The conscripts were being educated to become rifle unit soldiers. Their regular means of transportation was the combat vehicle PBV 401 which was used in the study. The participating conscripts had limited experience of riding in the armed vehicle at the time of the study. Their education and training were, in total, 10 months. This study was performed after they had completed 3 months of basic military training and they all had limited experience of riding in armoured vehicles in general. None of the participants had taken any precautionary antihistamines or other performance-affecting substances prior to the experiment.

2.2 Material

Two questionnaires were used, one “before transportation” and one “after transportation” questionnaire. Furthermore, a “background” questionnaire regarding age, target shooting experience, experience of previous motion sickness, and use of medication was used. The “before transportation” questionnaire consisted of a list of words describing different aspects of discomfort and uneasiness that could be associated with motion sickness, as shown in table 1.

Table 1: The "before transportation" questionnaire consisted of a list of words and their meaning in English

Swedish word	Meaning in English
huvudvärk	headache
sömnig	sleepy
hungrig	hungry
slö	indolent
yrsel	Dizziness/Vertigo
dålig matlust	low appetite
utsövd	thoroughly rested
törstig	thirsty
varm	warm
glad	happy
frusen	frozen
obehag (magen)	abdominal pain/uneasiness
svårt att fokusera	problems with maintaining focus
synproblem	visual problems
säker	safe
dålig balans	impaired balance
koordinerad	coordinated
koncentrerad	concentrated
lättirriterad	easily irritated
tvivlar på egen förmåga	doubtful of own ability
utmattad	exhausted
lugn	tranquil
stressad	stressed
orolig	worried
motiverad	motivated
mår illa	feel bad/nausea
kväljningar	nauseated

The "after transportation" questionnaire differed from the "before transportation" questionnaire in that it also asked the subjects to rate their

targeting performance, if they felt disoriented, and if they felt fit for fight when disembarking the vehicle.

2.3 Apparatus

The combat vehicles used were all PBV 401 (MT-LB modified for Swedish conditions). Combat vehicle PBV 401 is used for transportation of rifle units solely and takes between 8-11 soldiers depending on storage availability (see appendix A). The vehicle normally cruises in the terrain with speeds varying between 5-70 km/h and is completely armoured, which leaves the transportation room without any contact to the outside world. The equipment the soldiers were wearing was standard equipment for the Swedish army soldiers and included a standard uniform with a vest fitted onto the outside of the uniform containing weapon belongings and survival equipment. Fully functional, the soldiers' equipment weighted about 30 kilos and an extra 5 kilos for the rifle. The rifle that was used for target shooting was the AK5, which is the standard Swedish 5.56. calibre army rifle.

The shooting range used, was located at the training area and fully automatic, meaning that hits were registered automatically and displayed by a monitor next to the soldier. All shootings were performed from kneeling position since that is most common and gives good body support and flexibility (see appendix B). The targets were positioned on a 200 metres distance and consisted of regular scoring numbers in a circular order. The accuracy and spreading of the hits were automatically recorded and was shown on a monitor mentioned above. The monitor also showed the coordinates of each

hit, time between the first hit and every following hit. While the soldiers were shooting, the monitors were covered so that they couldn't see their individual results in order to avoid compensatory behaviour and biases from watching others.

2.4 Design

The study was a within-subjects repeated measurements design. The independent variable was perceived motion sickness and was studied using subjective ratings. The dependent variables were targeting performance, accuracy and spreading.

Targeting performance was considered to be an ecologically valid measure with high face validity. Target shooting is a regular activity for the conscripts and performed daily during their basic training. Being transported in the combat vehicle to a conflict area would also be one of the activities that the rifle soldiers could be exposed to. Targeting performance, measured as accuracy, was determined by counting the number of hits that was inside the target figure. Spreading was measured by observing the distance between the two outer most hits on the target.

2.5 Procedure

The participants had been informed about the study and its aim in advance by an oral briefing and gave their consent to participate. The conscripts had also been told not to take any precautionary actions such as antihistamines or anticholenergics and were only recommended to get a good night sleep and a normal breakfast the same morning, prior to the testing. When they arrived at

the testing area in the morning they were divided into three groups of equal size, each group assigned to a vehicle. All groups were informed on safety and military regulations concerning the day and after that the first group performed a baseline target shooting round. The shooting round consisted of 10 shots being fired within 30 seconds. Every group of soldiers started shooting on the order of an officer, but after the first shot they fired at will. After 30 seconds they were given the order to stop firing. Next they answered the *background* and *before transportation questionnaire*. Following the answering of the questionnaires, they embarked the vehicle and were transported through varying terrain for 30 minutes in approximately 25 km/h average speed. Each vehicle left the shooting range with approximately 20 minutes apart from another, in order not to get stalled when coming in for the test shooting. As soon as the vehicles had left the shooting area, the soldiers targeting results were noted from the monitor by one of the test leaders.

As soon as the first vehicle had left, the team awaited the second group and immediately started their target shooting. The same procedure as for the first group was repeated and when their vehicle left, the procedure was repeated again for the third group of soldiers. During the transportation the conscripts were given a task to perform inside the vehicle that consisted of a reading aloud a designated text. Each subject had to focus on the text and was thereby not given the time to prevent himself from getting affected by motion sickness. The reading aloud task was not added to provoke or create a conflict per se, but chosen in order to create a situation that would be representative to normal conditions.

When the first vehicle returned to the shooting range, the soldiers disembarked and ran a distance of about 75 metres to the same place where they shot from before. As soon as everyone had assumed kneeling position and indicated that they were ready, the officer gave the order “Fire!” and the soldiers fired 10 shots within 30 seconds. After 30 seconds they were given the order to stop shooting. Next they answered the first “after transportation” questionnaire. When finished, they waited outside of the shooting area. As soon as they had exit the shooting area, the soldiers targeting results were noted from monitor by one of the experiment leaders. The same procedure was repeated for the second and third vehicle and group. After approximately 3 hours of rest and lunch a second round of transportation was performed after the conscripts had shot the second baseline shooting. The procedure from the first round was repeated with one deviation from the earlier sequence, i.e., the transportation time was prolonged to last for 45 minutes instead of 30 minutes. The reason for this prolongation to 45 minutes was done to better adjust the average speed to the chosen route and also to se whether this prolongation had any effect on the conscripts perceived status.

2.6 Statistical analyses

One-way Anova, Spearman’s rank correlation and a three factor varimax rotated factor analyses were used, with the alpha level set to .5

3. Results

The three factor varimax rotated factor analysis was based on all four questionnaire occasions for all participants. The factor analysis distributed the words into three factors (see Table 2), here denoted as:

1. General psychological states,
2. Level of cognitive focus,
3. Physiological nausea symptoms

Table 2. The factor analysis distribution of the words into three factors and the factor loadings

Factor 1-3 and their loadings for each of the Swedish words

	Component		
	1	2	3
Q00_huvudvärk	-,042	,816	,045
Q00_sömnig	-,618	,115	,338
Q00_hungrig	,211	,092	,592
Q00_slö	-,544	,412	,397
Q00_yrsel	-,089	,570	,687
Q00_dålig matlust	-,181	,491	-,052
Q00_utsövd	,782	-,090	,045
Q00_törstig	-,053	-,100	,725
Q00_varm	,627	,060	,188
Q00_glad	,633	-,490	-,037
Q00_frusen	-,584	,076	-,080
Q00_obehag (magen)	-,166	,391	,380
Q00_svårt att fokusera	-,277	,599	,518
Q00_synproblem	,341	,161	,701
Q00_säker	,569	-,252	-,326
Q00_dålig balans	-,284	,078	,570
Q00_koordinerad	,437	-,004	-,128
Q00_koncentrerad	,592	-,376	-,237
Q00_lättirriterad	-,667	,039	-,055
Q00_tvivlar på egen förmåga	-,033	,610	,315
Q00_utmattad	-,454	,449	-,078
Q00_lugn	,326	-,010	-,516
Q00_stressad	,075	,509	,156
Q00_orolig	-,149	,774	-,187
Q00_motiverad	,608	-,056	-,308
Q00_mår illa	-,023	,643	,405
Q00_kväljningar	-,290	,378	,487

Factor 2
-Headache
-Low appetite
-Abdominal pain/uneasiness
-Problems with maintaining focus
-Doubtful of own ability
-Stressed
-Worried
-Feel bad/Nausea

The factor loading score on the factor 2, “Level of cognitive focus” correlated significantly with targeting performance, measured as shooting precision, $F(1,68)=4,70$ $p<.05$ (R-value .254, adjusted R^2: .051). This correlation was based on all four shooting occasions and indicated that high ratings on factor 2 was more common among those who also performed less well with regards to shooting precision. This was further supported by the fact that the

two baseline shootings also correlated with factor 2, F(1,33)=4,77 p<.05 (R-value: .355, adjusted R^2: .100) connecting the perceived physiological states in factor 2 with the time between the two transports (see Figure 1)

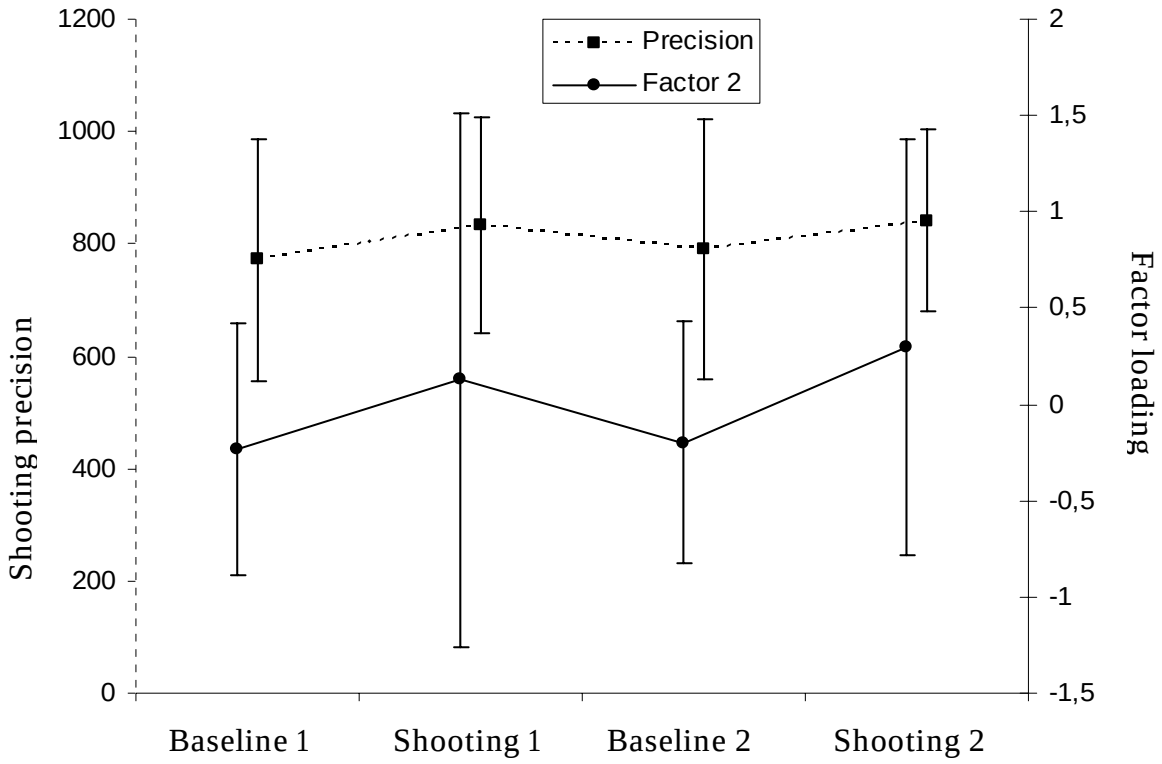

Figure 1. Shooting precision and factor 2 correlation

No differences were found with respect to the number of hits between the four shooting occasions.

The conscripts were asked to rate their perceived shooting performance after having performed each shooting. Their perceived performance, (see Figure 2), was not only rated lower after the second transport, F(1,17)=4,62 p<.05, but was also shown in their actual performance, i.e. impaired precision after the second transport.

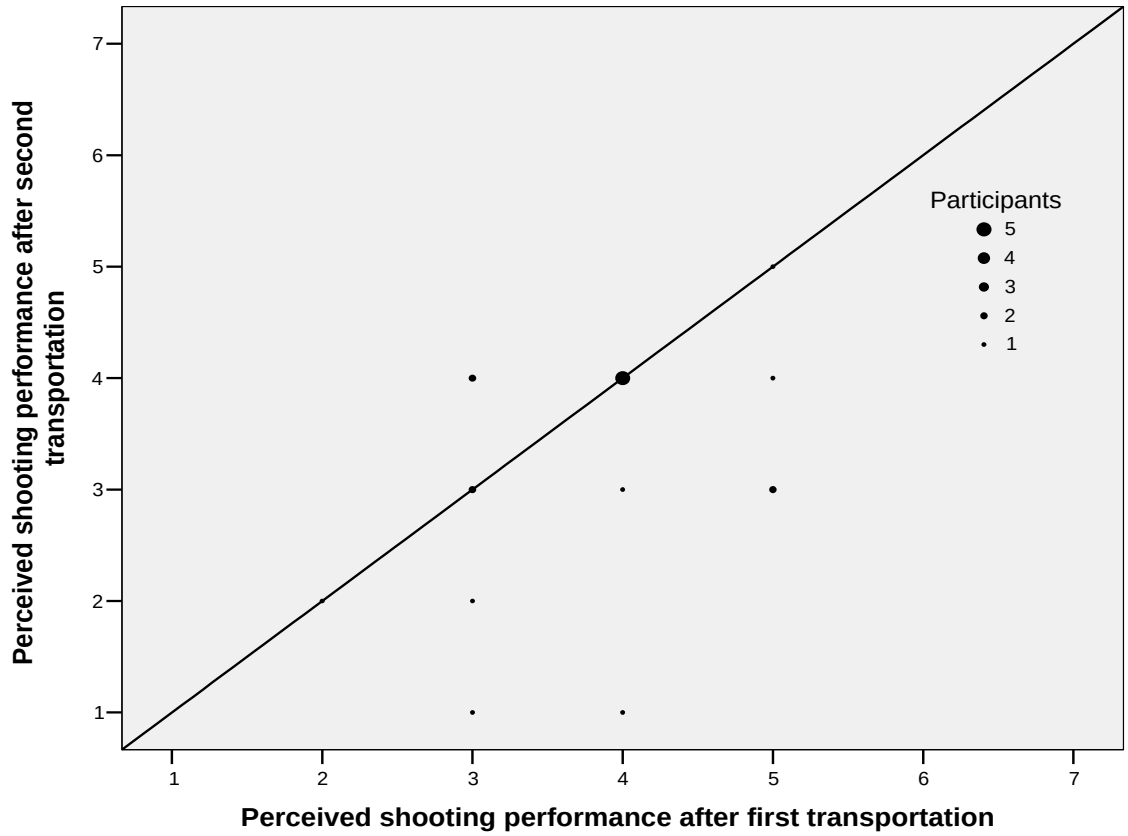

Figure 2. Perceived shooting performance after first and second transport (19 conscripts).

This result can also be supported by the fact that they experienced more discomfort (i.e. they were more affected by motion) after the second transport than after the first, $F(1,18)=5,16$ $p<.05$. The uneasiness also lasted for a longer time the second occasion (see Figure 3).

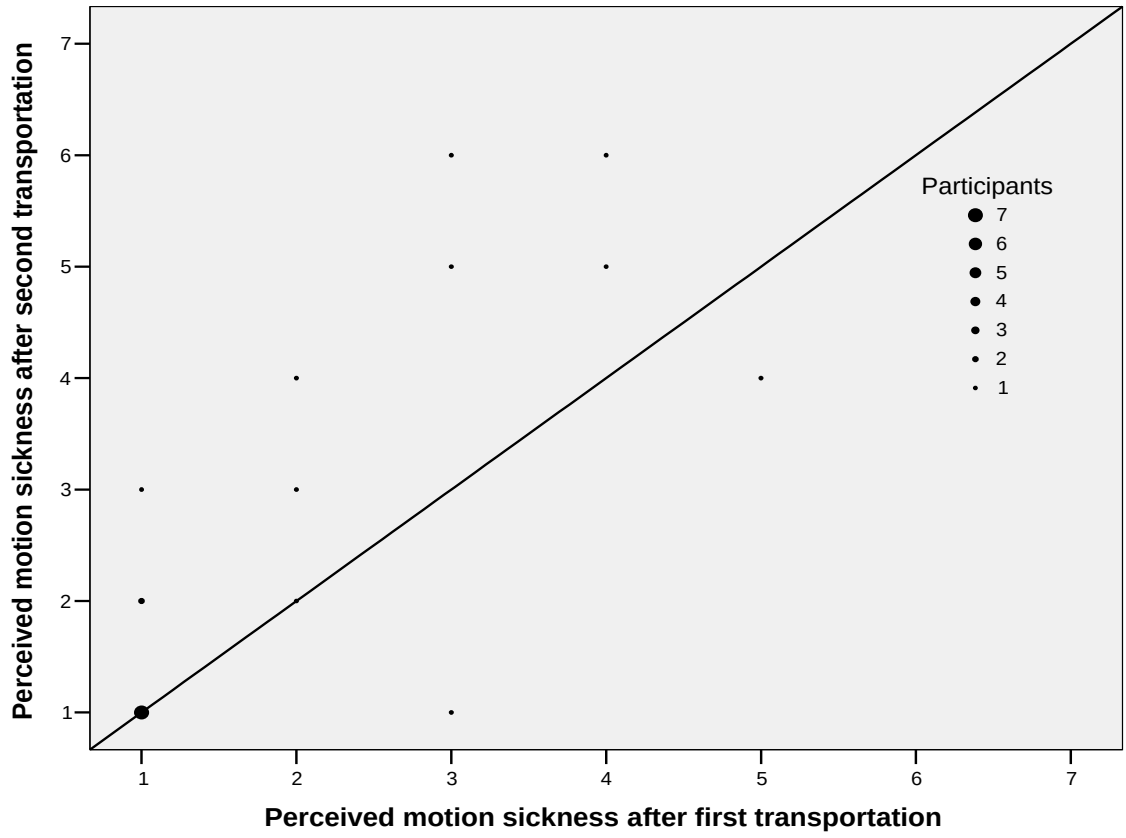

Figure 3. Perceived motion sickness after first and second transport (19 conscripts).

After the transport, the conscripts rated high on the combat readiness scale and reported that they did not feel disoriented as a result of the transport despite the fact that 50 % of the conscripts felt some kind of uneasiness during the first transport and 60 % during the second transport. It should be added that the terrains that were used for the transport were the same for both trials and the average speed was slightly lower for the second run than for the first.

4. Discussion

The aim of this study was to investigate targeting performance under the influence of motion sickness, in relation to self reported perceived motion sickness. The study was performed in a real and naturalistic setting and the conscripts were subjected to both subjective ratings and objective measurements concerning their performances. They were despite this more or less doing what they should have done anyway, as part of their education. This setting provided the subjects with high face validity and made them behave as normally as possible. It also made it possible to assign any motion sickness solely to the transportation, i.e. the intervention. To create a similar setting with the aid of simulation or virtual reality would not only have affected the behaviour of the conscripts, but would also have made it hard to assign induced motion sickness to the intervention only and not also to confounding variables such as simulator sickness or delay induced motion sickness, which occurs in virtual reality settings.

Despite provoking motion sickness by transporting the conscripts for 30 and 45 minutes, respectively, in bumpy terrain while reading and having no visual contact with the outside, the soldiers did neither report psychological states nor physiological nausea symptoms to the extent that we could correlate it to their decreased performances. We could, however, establish decreased shooting precision after being transported the second time and the conscripts also reported that they perceived it as such. The two baseline measurements also correlated with the significant factor, indicating that performance between the repeated measurements was also affected negatively. These findings

advocate that subjective ratings could play a role in early detection of decreased performances due to motion sickness. It is, however, obvious that subjective ratings are not the sole key for such identification, the correlation was fairly low. Also objective measurements are needed.

Most conscript reported an increased level of motion sickness after the second transportation compared to the first, advocating that the duration of the transportation is important for the occurrence of motion sickness. In the present study, the transportation duration was increased by 50% in the second trial, which yielded effects both on the subjective ratings, as well as the objective measurements, in this case shooting precision. The effects were, however, small and this could be due to the fact that the transportation did not induce enough motion sickness among the conscripts to affect both shooting precision and the number of hits. The best method to induce motion sickness is probably based on a combination of the amplitude of perceptual mismatch and exposure time. In this study, the amplitude was kept controlled on a fairly low level, while the exposure time was changed. We do not know the impact from the amplitude factor from this study. In future studies both duration and amplitude should be varied so that one of the two factors could be ranked as most important for induction of motions sickness.

With a higher frequency of motion sickness within the study population, the psychological, as well as the physiological aspects of self reported motion sickness symptoms could become significant in the factor analysis. Focusing on the latter, i.e. the physiological aspects, equipment to measure such parameters, such as the AFS II system (Cowings et. al, 1999), shown in

Figure 4, could be useful in future identifications of symptoms that could be correlated to early subliminal stages of motion sickness.

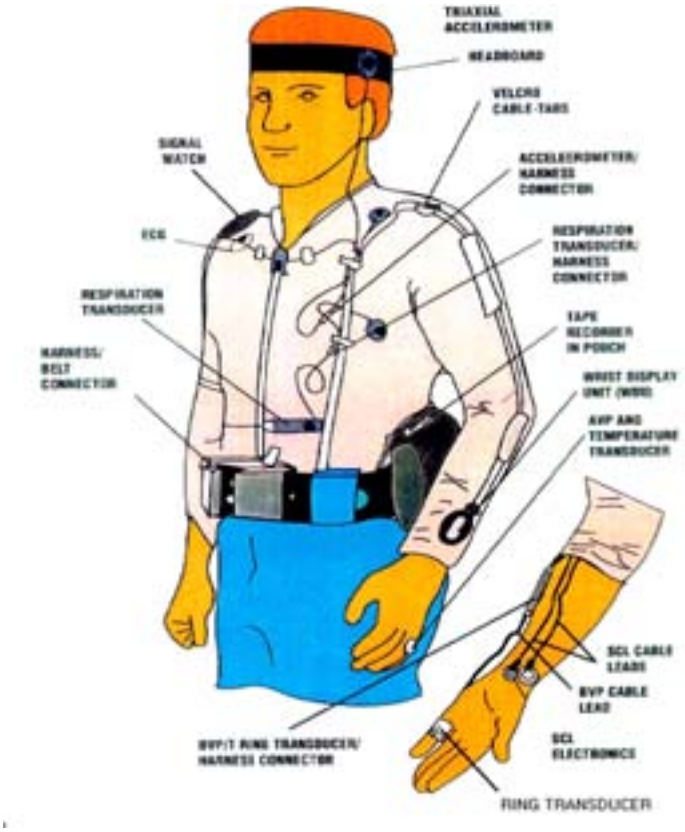

Figure 4: The Autogenic-Feedback System-2 (AFS-2)

The finding that it was the factor “level of cognitive focus”, i.e. cognitive aspects of performances that were most easily affected by the transportation is, in fact, intriguing. Could it be that the cognition initially is, actually, being affected by early stages of motion sickness, prior to more physiologically and psychologically related factors? With the aid of measurement equipment, such as the one shown in Figure 4, combined with self rating questionnaires in laboratory settings were motions sickness is induced, could probably provide an answer on this issue.

A drawback with the present study was that the number of conscripts was low. Future studies should include more subjects, and also use an index of the number of hits, their position on the target boards and the spreading of the shots, i.e. the precision. In a real combat situation, hitting the target at least once is probably more important than having low spread of the shots, if the spread is within the wrong area. As mentioned previously, in this study we could not identify a decrease in performances with respect to hitting the targets, due to transportation induced motion sickness. Future studies should thus include a range of difficulties to hit the targets so that also minor decreases in hitting performances could be detected from that point of view.

5. Conclusion

The self reported factor “Level of cognitive focus” correlated with decreased shooting precision in the present study, in which the conscripts also subjectively reported less shooting accuracy when perceiving a higher rate of motion sickness. This leads to the notion that self reported motion sickness provides information on performance, but that is not the sole measurements that should be used. Instead there is a need to combine it with objective physiological measurements. The present study also supports the idea that motion sickness and its effect on performance should be studied by using actual performance measurements as a compliment to subjective ratings.

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Appendix A

The PBV 401 (MT-LB modified for Swedish conditions).

Appendix B

The 200 meters shooting range with automatic registration