Motion Sickness Reduction through Vibro-motor Reprocessing Therapy: A First Study

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***Abstract*— In order to reduce motion sickness (MS), a novel vibro-motor reprocessing therapy (VRT), based on an Eye Movement Desensitization and Reprocessing (EMDR) technique is investigated. To the best of the authors knowledge, this is the first time that reprocessing therapy has been evaluated for alleviating MS. Experimentally, MS was induced using visual stimulus of motion videos. Subjective MS was then recorded at baseline for both VRT and non-VRT stimulation conditions, and after each condition, evaluated using a Motion Sickness Assessment Questionnaire (MSAQ). MSAQ scores were compared for both conditions in eight test subjects, with a significant and clear reduction in motion sickness symptoms revealed when applying VRT stimulation. While the subject pool is small, this pilot study indicates that the proposed approach has potential for future exploration in terms of non-pharmacological treatment and management of MS.**

I. Introduction

Motion sickness is a major issue for the people who are prone to the ailment. Approximately 30% of the population is naturally immune to motion sickness [1,2] – unfortunately for the rest of us, it is a problem that can only be treated, not *cured*. We believe that this problem is set to be exacerbated in future with the increasing adoption of autonomous vehicle technology in which passengers reportedly feel increased sickness when sitting in front but not driving [3].

Well-known symptoms of motion sickness are due to different kinds of stimuli: travelling by car, plane, train, or in space. Some people experience it after chemo treatment [4]. Research has found that motion sickness can also be due to console-based video games [5]. There exist various forms of remedies said to help alleviate motion sickness, ranging from looking further into the horizon, keeping eyes closed, napping, chewing ginger and acupressure, among others.

Motion sickness is often thought to manifest itself with initial signs and symptoms of nausea and vomiting followed by a range of other symptoms. *Other* symptoms may include headache, eyestrain, pallor, sweating, ataxia and vertigo.

Motion sickness countermeasures can be classified as either behavioral or pharmacologic. Pharmacologic measures include over-the-counter medications such as those containing antihistamines, anticholinergics, and serotonin; and are effective at preventing motion sickness. However, most current measures do little more than induce drowsiness. Behavioral measures could comprise habituation, reprocessing or desensitization treatment protocols, among others [6]. The purpose of this study is exploring and effectively reducing motion sickness/nausea by using non-invasive reprocessing therapy based on alternating vibrating stimulations in both palms – this therapy was originally used in psychological counselling studies and is based on eye movement. It is commonly termed Eye Movement Desensitization and Reprocessing (EMDR) [7].

II. Background

A. Eye Movement Desensitization and Reprocessing

This psychotherapeutic technique originated in 1987. The technique is a development and research contributed by psychologist Francine Shapiro [8]. Since its inception, and with no negative side effects, EMDR has found increasing use professionally, and is currently being utilized by agencies such as the US Departments of Defense and Veterans Affairs [9]. Moreover, it is used by governing bodies such as the World Health Organization (WHO) [9]. Although it was used initially as a treatment towards traumatic memories experienced by people, its usage spectrum now includes a variety of disorders such as Post-Traumatic Stress Disorder (PTSD) in addition to depression, among others [10].

Essentially, EMDR therapy works by facilitating information processing of traumatic situations or memories through adaptive information processing (AIP). Thus, previously unprocessed information in the information processing system is reprocessed [11]. EMDR treatment sessions are lengthy, lasting up to 90 minutes [12] and often require repeat sessions.

The application of EMDR therapy in treating PTSD has been recognized as a safe to use psychotherapy choice for children, teenagers and adults [13]. Although the use of EMDR derivatives, e.g., the vibro-motor reprocessing therapy (VRT, as coined by us) in our study, follows procedural protocol that differ from those used to treat PTSD, it is a safe and mainstream therapy (for example, offered by the National Health Service in the UK [14] for other conditions). As a benign regimen, it may be particularly useful for children (who tend to be more motion-sickness-prone) as well as those with other physical and mental health conditions [14].

B. Visually Induced Motion Sickness

Visually Induced Motion Sickness (VIMS) can be classified as another motion sickness type. It manifests itself through nausea (a primary symptom of motion sickness), oculomotor strain and disorientation.

C. Objective

In this study, we evaluate VRT stimulation response to motion sickness induced by VIMS. We focus our analysis on

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16 motion sickness symptoms activated using a motion video visual stimulus. We investigate which motion sickness symptoms from the gastrointestinal, central, peripheral and sopite-related areas can be suppressed or reduced by VRT stimulation, as assessed by a Motion Sickness Assessment Questionnaire (MSAQ). The study in [15] validates MSAQ efficacy for assessing motion sickness.

III. Methodology

A. Participants

A total of eight volunteering participants were invited to this study. All participants had perfect or corrected vision. Participant cohort were four males and four females, with mean age of 29.88 and standard deviation of 12.8 years. Participants were asked to give written consent before any study-related activity and were eligible to withdraw their participation in the study at any given time without providing any reason. Only participants fulfilling the inclusion criteria were invited to the study. Ethical approval to conduct the study was received from the University of Kent Faculty Research Ethics Advisory Group for Human Participants (Project Identification Reference: 0082021). All the studies performed conformed to The Code of Ethics of the World Medical Association set by the Declaration of Helsinki.

B. Experiment Settings

This study uses a visual stimulus created as a compilation of four shorter videos to build a 10-minute video. The visual stimulus induces a spinning-like sensation continuous on a spot, to the participant. The full-length video was compiled from a personal computer with Adobe Premiere Pro (San Jose, USA). The motion video was delivered on a Galaxy S8 smartphone snapped into Gear Virtual Reality (VR). EMDR stimulation was generated through a Tactile Unit plugged into a Boka 9 EMDR device (EMDR Equipment Europe, UK). Fig. 1 shows the EMDR equipment used in this study.

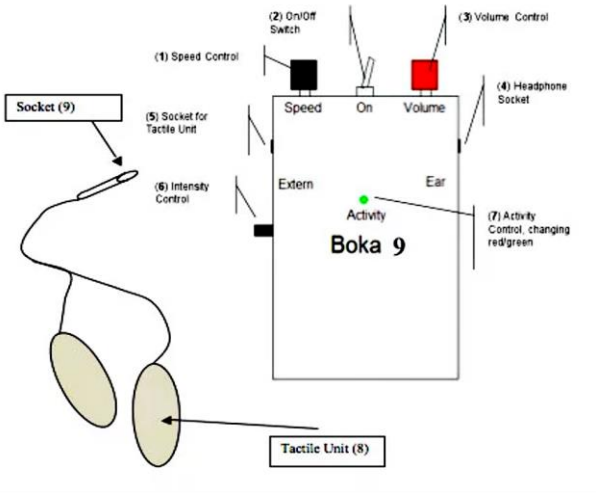

Figure 1. VRT stimulation unit

C. Data Acquisition

The experiment was conducted while participants were comfortably seated and visual stimulation presented to them using the Gear VR, for both experiment sessions. During the VRT stimulation session, participants were asked to rest their hands comfortably on their thighs, palms up. The Tactile Unit was placed on the palms of the participant to allow for a comfortable grip.

Fig. 2 shows the VRT experimental protocol in this study. The experimental procedure included two sessions conducted on separate days. The first session was composed of two tasks: an eye open task for 5 minutes (baseline) and watching the motion video for a possible maximum of 10 minutes or until moderate nausea was experienced. The second task was highly dependent on the individual participant and their susceptibility to motion sickness. As soon as the participant felt uncomfortable, the presentation of video stimuli was stopped immediately.

The second session was also composed of two tasks: an eye open task for 5 minutes (baseline), then watching the motion video while undergoing VRT stimulation simultaneously (again for a possible maximum of 10 minutes). Participants completed the MSAQ [16] before each baseline task, after watching the motion video in session one and after simultaneously watching the motion video and undergoing VRT stimulation in session two.

These session types were alternated randomly between the participants.

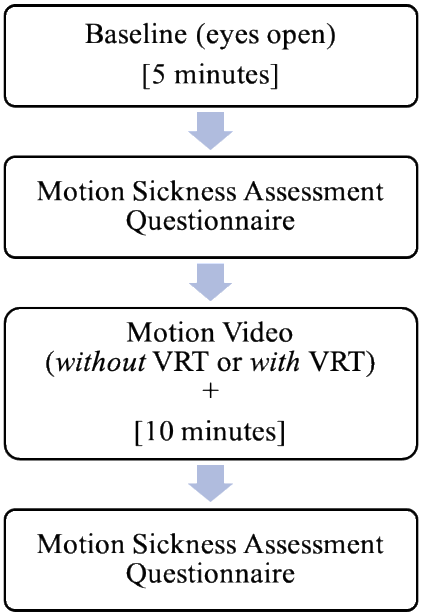

Figure 2. VRT experimental protocol

D. Data Analysis

The MSAQ assesses the severity of exposure to motion sickness using a nine-point scale (1 being an experience of 'not at all' and 9 being 'severely') across 16 items. MSAQ contains the Gastrointestinal, Central, Peripheral and Sopite-related subscales. The final score for motion sickness severity is calculated as a percentage of total points obtained: (sum of points across all items/144) x 100.

The percentage of scored points against each factor is computed in order to find out the subscale score, thus, we calculate the sum of gastrointestinal, central, peripheral and sopite-related items respectively, then apply a division by

respective totals of 36, 45, 27, 36 and finally multiply respectively by 100 to obtain a calculated percent of points.

The MSAQ score can thus range from 11.1% to 100%. An MSAQ score of 11.1% indicates that there is no evidence of motion sickness whereas a score of 100% concludes to a most severe case of motion sickness.

To explore the changes of MSAQ scores across all four subscales and the total correlates of nausea-related and VRT-related changes in visual stimuli exposure, we computed the following metrics within the BASELINE and NAUSEA, and BASELINE and VRT analysis windows for each participant. The means of MSAQ scores subscales were calculated for all participants recorded as fractional changes defined as (NAUSEA-BASELINE)/BASELINE and (VRT-BASELINE)/BASELINE for Gastrointestinal, Central, Peripheral and Sopite-related. Non-parametric statistical tests were used to analyze the data, since normality of data was not assumed. Statistical analysis was carried out using MATLAB R2020b (MathWorks Inc., USA).

IV. Results and Discussion

A total of eight participants were included in the study with no dropouts. All participants completed the study without vomiting. Despite the small sample size, the results of the study were consistently in the same direction. Based on the MSAQ scores, the motion video provoked visually induced motion stimulus (VIMS) of at least 20% and a mean score of 37.5% across all participants.

All participants were symptomatic, i.e., participants reporting at least one symptom from a collection of the 16 symptoms that are in the MSAQ. Some of the participants reported mild cases of headache after the experiment conducted without the VRT stimulation. After the VRT stimulation, by contrast, the same participants reported no mild discomfort of any sort.

TABLE I. Comparison of MSAQ scores in two conditions

Participant	Gender	Total MSAQ scores		
		Without VRT (%)	With VRT (%)	Difference (%)
P1	F	38	21	17
P2	M	42	26	16
P3	M	50	15	35
P4	M	20	13	7
P5	M	59	20	39
P6	F	22	20	2
P7	F	23	14	9
P8	F	46	38	8
Average		**37.5**	**20.9**	**16.6**

MSAQ scores between *with VRT* and *without VRT* conditions across the four subscales (gastrointestinal, central, peripheral, sopite-related) and total score were compared for the effectiveness of VRT stimulation as shown in Table I and Fig. 3. It can be seen from Fig. 3 that there is a significant drop for the Sopite category. Research has found a relationship between motion sickness and drowsiness (so-called *sopite* syndrome) [17]. There was an improvement of at least 2% on the MSAQ total score (with average of 16.6%) for experiments conducted with respect to VRT stimulation scores across the participants. Participant 5 had the highest improvement of 39% - this was the participant that felt very uncomfortable without VRT and stopped the motion video early on (around 5 minutes) but lasted until the end with VRT (i.e. 10 minutes) without any discomfort.

It can also be seen that median values for each subscale and total MSAQ scores for the VRT stimulation session were lower than for the non-VRT session. It is also evident that the range of the data for the VRT session was much reduced compared to the non-VRT session, as shown in Fig. 3. This indicated that VRT consistently reduced motion sickness symptoms for all participants.

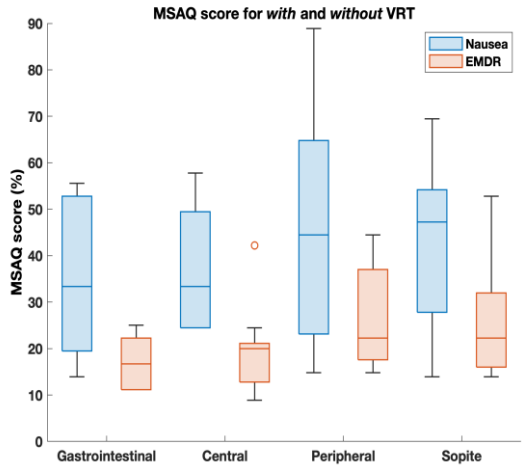

Figure 3. Average MSAQ score for *with* and *without* VRT stimulation

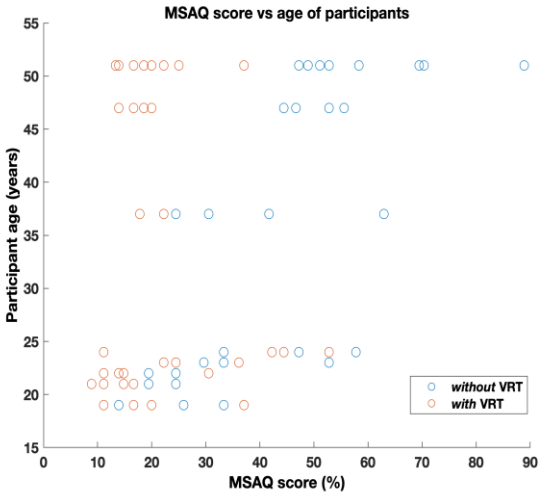

Figure 4. MSAQ scores for the four categories; Gastrointestical, Central, Peripheral, and Sopite against participant age in two conditions

Differences in the totals of the scores between the two conditions could not be tested for significance given the low

number of participants. However, the symptoms of motion sickness from the two conditions were significantly different. A Wilcoxon signed rank test indicated sufficient statistical evidence to conclude that the median MSAQ scores (using scores from all the four categories) after VRT stimulation were less than the median MSAQ scores without VRT stimulation ($p = 0.0078$).

Fig. 4 displays the relationship between participants' ages and severity of motion sickness symptoms. As can be seen from the figure, older participants showed a greater range of values in the subscales compared to younger participants. It can also be seen that the use of VRT reduced this range for all participants, thereby indicating positive effects irrespective of age, although a larger sample size is required before this effect can be conclusively demonstrated.

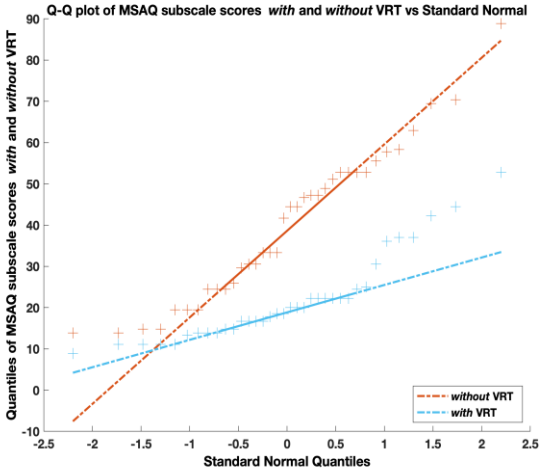

Figure 5. QQ Plot of MSAQ scores across the four subscales for all participants

Fig. 5 shows the quantile-quantile plot for the MSAQ scores across the four subscales for all the participants. It can be seen that without VRT, the distribution was normal. The VRT conditions were positively skewed showing that most of the MSAQ scores were smaller among the participants. The lower slope with VRT shows that the standard deviation of the scores was smaller as compared to without VRT, again illustrating consistent values for all participants.

V. Conclusion

In this study, we have demonstrated that motion sickness symptoms can be reduced through VRT stimulation – a non-pharmacological, portable and easy to apply treatment. Motion sickness was induced visually in eight volunteers, using a VR headset. VRT stimulation was applied using Boka 9 Tactile Unit EMDR equipment, and motion sickness symptoms were assessed by MSAQ. Despite the small sample size, VRT led to a statistically significant reduction in symptoms.

In future, we plan to investigate these effects using a larger number of participants, and further study the positive effects of VRT stimulation in reducing motion sickness symptoms induced by VIMS. Furthermore, VRT demands further investigation to understand how it causes these physiological changes. Research has studied psychophysiological changes concurrent with VIMS, using a motion video, theorizing evident statistical differences between participants developing nausea compared to ones who do not [16]. Our future research will extend to analysis of such psychological measures repeated over multiple sessions.

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