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Chapter 4

Equally moved and not really sick from viewing 2D and 3D motion stimuli on a TV screen

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Abstract

Objective. Visually induced motion sickness (VIMS) and increased postural sway are two adverse side effects that may occur when viewing motion stimuli. However, whether these effects are elevated to a greater extent when viewing stereoscopic 3D motion stimuli, compared to 2D stimuli on a TV screen, has not been investigated under controlled circumstances. Therefore this study aimed at investigating VIMS and postural sway before, during, and directly after viewing 2D and 3D motion stimuli, on a commonly available TV screen.

Methods. 16 Participants were exposed to an aviation documentary shown in 2D and in 3D on separate occasions. Before, during, and after exposure, VIMS and postural sway were measured. VIMS was quantified by a rating scale giving a single number, and by a multi-symptom questionnaire that assessed multiple VIMS symptoms separately. Sway path length, standard deviations and short-range and long-range scaling components of the centre of pressure were calculated as measures of postural sway.

Results. VIMS symptom severity, as obtained with the single rating scale, did not show a significant increase to either 2D or 3D exposure. The multi-symptom questionnaire did reveal significant increases in VIMS symptom severity to both 2D and 3D exposure. However, VIMS was not significantly more increased in case of 3D exposure compared to 2D exposure. All postural sway measures (sway path length, standard deviation in mediolateral and anteroposterior direction, as well as the short-range scaling components) increased significantly as a result of exposure. None of the postural sway measures was differentially affected to 3D as compared to 2D exposure.

Conclusions. Viewing 3D motion stimuli did not cause more serious VIMS symptoms, compared to viewing motion stimuli in 2D. We attribute this lack of difference to the fact that the 3D effects in this documentary were optimized for viewing in a cinema, the projection on the TV-screen thus causing quarantining of the visual input. The increase in postural sway, irrespective of image type, may reflect exploratory behaviour, allowing the participant to gain more information about self-orientation with respect to the virtual environment.

4.1. Introduction

Nowadays, thanks to spectacular technological improvements, 3D stereoscopic technology is implemented on a regular basis, and has entered the living room with the introduction of commercially available 3D TVs. However, with these developments the concern over possible adverse effects due to prolonged exposure to 3D motion stimuli has increased. This study aims at jointly investigating two possible adverse effects of viewing 3D, compared to viewing 2D, on a common TV screen.

Exposure to motion stimuli, either in 2D or 3D, can cause symptoms similar to those associated with motion sickness, also called visually induced motion sickness (VIMS)[15,41–45]. VIMS is a condition in which viewers experience oculomotor, disorienting and especially nauseating symptoms due to exposure to certain visual patterns, while being physically stationary[15,41–43]. In addition to VIMS symptoms, viewing motion stimuli can also affect postural control, defined as "the act of maintaining, achieving or restoring a state of balance during any posture or activity"[22]. In particular it has been shown that postural sway increases due to viewing 2D[21,35,54,121] and 3D motion stimuli[33].

An influential theory explaining the origin of VIMS is the sensory conflict theory[2,39,40]. According to this theory, VIMS symptoms arise when there is a mismatch between sensory signals from the visual, vestibular and somatosensory senses and the expected sensory signals[2,39,40]. In daily life the signals from these senses correspond with each other, and are also congruent with the expected sensory signals based on an internal model. However, when viewing 2D or 3D motion stimuli whilst sitting or standing still, the visual cues do not coincide with the vestibular cues and are also not in line with the expected sensory signals. This conflict between the sensory signals and expected sensory signals is proposed to cause VIMS. It has been suggested already that especially visual motion indicating a change in the Earth-vertical is necessary to cause VIMS[2,62,107]. Next to such visual motion, in this paper we propose that viewing 3D motion stimuli exacerbates VIMS compared to viewing visual motion stimuli in 2D.

3D motion stimuli contain, compared to 2D motion stimuli, stereoscopic information which is proposed to be the additional provocative factor with respect to VIMS symptoms (see e.g.[48,122,123]). The stereoscopic information is known to add to the naturalness of the 3D motion stimuli[18,124]. Because 3D motion stimuli appear more natural, a larger conflict between the sensed and expected sensory signals is suggested (see also [47]), therefore causing more severe VIMS symptoms as compared to 2D. Several earlier studies have investigated the effect of viewing stereoscopic 3D stimuli, compared to viewing 2D stimuli. In these studies participants were exposed to computer generated stimuli or a movie, that was shown in 2D and 3D on either a projection screen, at the cinema or on a TV-screen[15,17,55–57]. Despite the large differences in stimuli and displaying techniques, in all studies

participants experienced significantly more severe VIMS symptoms after viewing 3D motion stimuli compared to 2D motion stimuli[15,17,55–57].

VIMS and postural sway have been jointly studied, mainly using 2D stimuli. The majority of these studies reported a significant rise in VIMS symptoms as well as increased postural sway (e.g.[21,35,54,121]). To the best of our knowledge only Bos et al.[33] studied VIMS and postural sway characteristics prior to, and after viewing 3D motion stimuli. They found that, after viewing a 3D documentary in a cinema, VIMS and postural sway were significantly increased compared to before viewing. Unfortunately, Bos et al.[33] were not able to make a comparison with 2D presentation, impeding a direct comparison of potential adverse effects of 3D viewing to 2D viewing on both VIMS and postural sway.

In summary, exposure to both 2D and 3D motion stimuli are able to cause VIMS symptoms and increase postural sway. However, an experiment comparing VIMS, as well as postural sway induced by viewing 2D and 3D motion stimuli is still lacking. To address this gap in the literature, in this paper we investigate subjective reports of VIMS symptoms and postural sway in one group of participants, who are exposed to the same motion stimuli shown in 2D and 3D on a commonly available TV-screen. Based on the existing literature, we hypothesize that prolonged exposure to both 2D and 3D motion stimuli will increase symptoms of VIMS, and we predict 3D to cause more VIMS related symptoms in comparison to 2D exposure. We also expect postural sway to significantly increase when viewing both 2D and 3D. However, whether postural sway will also increase more when viewing 3D compared to viewing 2D remains to be seen.

4.2. Methods

4.2.1. Participants

Sixteen healthy young adults (*N* = 16) of the Faculty of Human Movement Sciences of the VU University Amsterdam participated in this study. Participants were 5 males and 11 females with a mean age of 21.5 (*SD* = 1.32) years. All participants signed an informed consent form before participation. The ethics committee of this same faculty approved the study in accordance with the Declaration of Helsinki.

4.2.2. Stimuli

Participants watched the aviation documentary 'Legends of Flight', with ample scene motion in all degrees of freedom, previously shown to cause VIMS in an unselected sample of cinema goers[33]. The documentary lasts 45 min, and in the current experiment it was viewed in two separate sessions, once in 2D and once in 3D, using a commonly available 55-inch TV-screen (LG 55LA8609). 3D was realized using (light-weight) passive circular polarized glasses as provided by the manufacturer. Participants were seated at a distance of 1.34 m from the screen, yielding a field of view

of 48 by 28˚ (horizontal x vertical). To minimize the differences between sessions, we originally aimed at using the glasses also in the 2D session (possibly using equal glasses for both eyes). This, however caused a grid of thin lines to become visible, which was not present in 3D. We therefore chose to use no glasses at all in the 2D session.

4.2.3. Measurements

4.2.3.1. Subjective misery

Three sickness measurements were included. First, the motion sickness susceptibility questionnaire (MSSQ) was filled out prior to the experiment, in order to assess a potential history of motion sickness over the lifetime. The MSSQ assesses previous occurrences of motion sickness in cars, buses, trains, aircrafts, boats, swings, roundabouts and theme park rides up to the age of 12 and for the last 12 years. The MSSQ score has a minimum of 0, implying no problems whatsoever, and a maximum of 222, implying severe problems in all above situations. The 50th percentile of a normal population corresponds to a MSSQ score of 37[81,82].

Second, before and right after the experiment, VIMS was assessed using the simulator sickness questionnaire (SSQ)[42]. With the SSQ, the severity of 16 sickness symptoms is rated on a 4-point scale ranging from 0 to 3 (none, slight, moderate, severe). Outcome measures of the SSQ are expressed in three subscales, representing distinct symptom clusters of simulator sickness (nausea, oculomotor and disorientation), and a total score (TS) that represents overall discomfort.

Third, misery scale (MISC)[82] rates were obtained before, during and right after the experiment. In this case, participants were asked to report their symptoms on an 11-point scale, ranging from 0 to 10. A score of 0 represents absence of symptoms, a score from 1 to 5 represents with increasing severity any symptom except nausea; a score of 6 or higher represents an increasing severity of nausea with 10 when vomiting. The MISC makes use of the observation that sickness symptoms other than nausea may vary largely between participants, and if present, generally precede nausea[82]. The advantage of the MISC over the SSQ is that it is scored using one value only, and hence can be administered within a short period of time.

4.2.3.2. Postural sway

Postural sway was quantified by measuring excursions of the centre of pressure (CoP). A custom made 1 x 1 m strain gauge force plate (resolution: 0.28 N/bit) was used to collect 60 s CoP time series at 100 Hz. Participants were instructed to stand still with their arms hanging alongside their torso, head upright, and eyes closed. Feet were positioned at an angle of 30˚ with the heels together as depicted on the force plate.

All postural sway measures were calculated using Matlab R2014a.

Onset-effects were ignored by excluding the first 5 s of each CoP time series. From these time series, a number of global, as well as structural or fractal properties of postural sway were calculated. As global measures we calculated (1) the sway path length (SPL), defined as the length the CoP travelled over the measurement interval, and (2) standard deviations (SD) of the CoP signal in anteroposterior (AP) and mediolateral (ML) directions. Before calculation of these global measures the time series were filtered with a 2nd order low-pass Butterworth filter with a cut-off frequency of 5 Hz. As a structural or fractal measure (3), scaling components of the raw (i.e. not filtered) CoP velocity were calculated for AP and ML directions, using a detrended fluctuation analysis (DFA)[83–85]. With these scaling components insight was obtained into the serial correlation properties of the CoP time series[84]. Based on two earlier studies that found a difference between short-range and long-range scaling components[84,85], two intervals ranging from 0.3 s to 0.8 s (α_s; short range) and 3 s to 8 s (α_l; long range) were chosen. Persistent behaviour of the CoP velocity is represented by a scaling component above 0.5, i.e. a positive CoP velocity at a certain moment is on average followed by more positive velocities, and vice versa. The opposite, anti-persistent behaviour, is represented by a scaling component below 0.5. More information on the DFA over the CoP velocity can be found in e.g.[49,84].

4.2.4. Procedure

Participants took, in a counterbalanced order, part in two sessions on separate days with at least one day in between sessions. In one session participants watched the aviation documentary in 2D and in the other session the same documentary in 3D. For reasons mentioned above, participants wore the polarized glasses only in the 3D session.

Preceding the first session, participants were informed about the experimental procedure, signed an informed consent, and filled out the MSSQ. At the beginning of each session participants memorized the possible MISC rates with their corresponding symptoms and practiced one CoP measurement with eyes closed. As a baseline measurement (labelled "pre") participants filled out the SSQ, reported their current MISC rate, and a 60 s CoP measurement with eyes closed was obtained. Participants watched the entire documentary while seated, in an otherwise darkened room. The documentary was divided into three equal blocks of 15 min. After each block, the documentary was interrupted for 90 s, during which participants reported a MISC rate and a (60 s) CoP measurement with eyes closed was obtained (labelled "per-1", "per-2", and "post" respectively). In other words, the measurements per-1 and per-2 were obtained in between blocks of exposure. If participants felt fairly nauseated or worse during exposure (MISC ≥ 7), the documentary was paused and participants rested for three minutes, after which it was continued until the end of the block.

These preventive measures were taken in order to keep the duration of exposure and the number of measurements constant for all participants. After the entire documentary (post) the SSQ was filled out again.

4.2.5. Data analyses

IBM SPSS Statistics 20 was used for statistical analyses. In order study the effects of measurement moments (pre, per-1, per-2 and post) and session (2D and 3D) on sickness ratings, multiple non-parametric two-tailed Wilcoxon 2-related samples tests were conducted. For each session the SSQ-TS collected post-exposure was compared with the SSQ-TS obtained pre-exposure, resulting in one test for each session. In addition, for each measurement moment (pre and post) the two sessions (2D and 3D) were compared, resulting in another pair of tests. For each session the MISC data during (per-1 and per-2) and post-exposure were compared to the pre-exposure measurement and for each measurement moment the two sessions (2D and 3D) were compared. A Bonferroni correction was applied to correct for the multiple comparisons.

To study the effects of measurement moment (pre, per-1, per-2 and post) and session (2D and 3D), separate 4 x 2 repeated measures ANOVAs were performed on the postural sway measures. When appropriate, simple contrasts (i.e. differences with respect to the pre-exposure measurement) were used to identify where specific differences occurred. Partial eta-squared (η_p^2) was calculated to determine the effect size. All variables appeared to meet the assumption of normality as checked with Kolmogorov-Smirnov tests and by visual inspection of boxplots and q-q plots.

4.3. Results

4.3.1. Subjective misery

The MSSQ scores obtained prior to the experiment ranged from 0 to 152 with the 50th percentile being a MSSQ score of 31. SSQ-TS obtained directly after exposure were significantly increased compared to before exposure, $Z = 2.78$, $p = .005$, $r = .70$, and $Z = 2.90$, $p = .004$, $r = .73$ for the 2D and 3D sessions respectively (Fig. 4.1a). Analysis of the SSQ subscales revealed that the reported symptoms were mainly of oculomotor and disorientation origin (Fig. 4.1b). No differences were found between the 2D and 3D sessions for the total score and subscales. Note that the p-values were Bonferroni corrected for multiple tests ($n = 4$), resulting in a significance level of .0125.

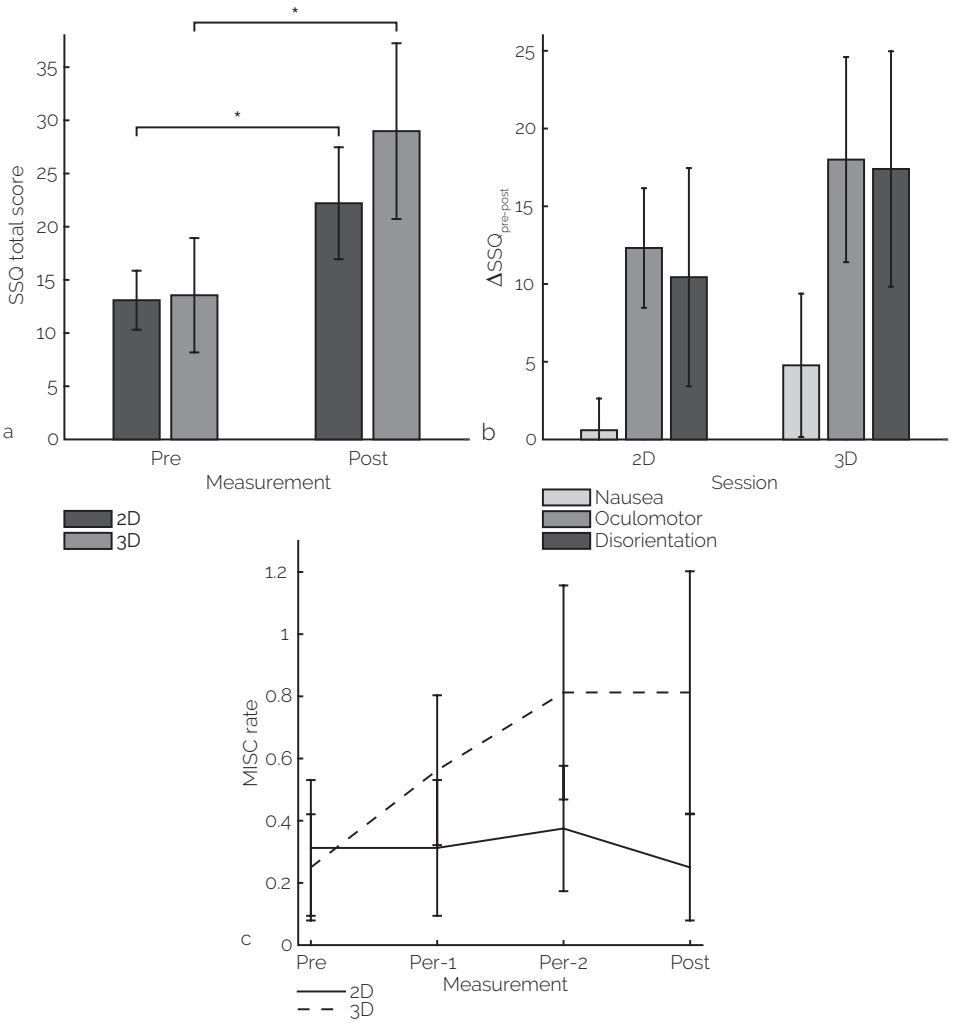

Figure 4.1. Mean scores of the two VIMS questionnaires, the simulator sickness questionnaire (SSQ) and misery scale (MISC). **a.** The SSQ total scores were significantly increased directly after exposure to both 2D and 3D motion stimuli. **b.** Pre-post difference scores on all subscales for the 2D and 3D session. The increase in SSQ total scores was mainly caused by increased scores on the oculomotor and disorientation subscale. **c.** MISC rates did not significantly increase. No differences between the sessions were observed for the SSQ or the MISC. Significant differences at $p < .05$ are indicated with an *.

MISC rates reported in the 2D session ranged from 0 to 3 (slight symptoms), while in the 3D session they ranged from 0 to 6 (slight nausea; Fig. 4.1c). Statistical testing showed that both increases were, however, not significant, $Z = 2.04$, $p = .041$ and $Z = 2.06$, $p = .039$ respectively. Note that the significance level was again Bonferroni corrected for multiple tests ($n = 10$), resulting in adjusted alpha level of .005. Furthermore, the MISC rates did

not significantly differ between the 2D and 3D session.

4.3.2. Postural sway measures

4.3.2.1. Global measures of postural sway

Time courses of the SPL and SD in AP and ML directions are shown in Figs. 4.2 and 4.3, respectively. Statistical analysis revealed significant main effects of measurement moments for both the SPL, $F(3, 45) = 3.75$, $p = .017$, $\eta_p^2 = .20$, and the SD in AP and in ML directions, $F(3, 45) = 3.69$, $p = .018$, $\eta_p^2 = .20$ and $F(3, 45) = 3.78$, $p = .017$, $\eta_p^2 = .20$ respectively. The SPL, as well as the SD in AP and ML directions, were significantly elevated during (per-1 and per-2) and after exposure as compared to the values obtained pre-exposure (Table 4.1). No differences were found between the 2D and 3D sessions.

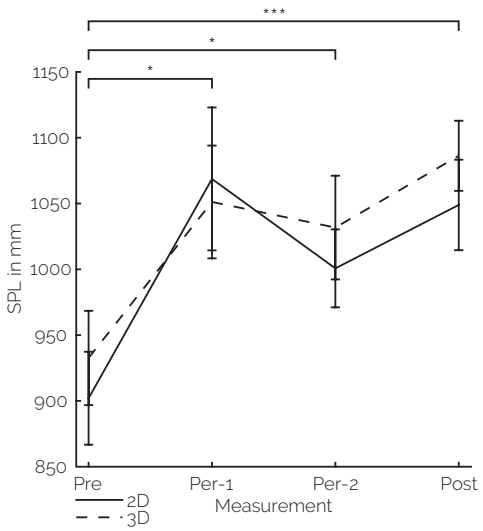

Figure 4.2. The sway path length (SPL; mm, ± SEM) for all measurements, separate for viewing 2D (solid line) and 3D (dashed line). For both 2D and 3D, after all blocks of exposure (per-1, per-2, post) the SPL was significantly increased compared to pre-exposure. Significant differences at $p < .05$ are indicated with *. Significant differences at $p < .001$ are indicated with ***.

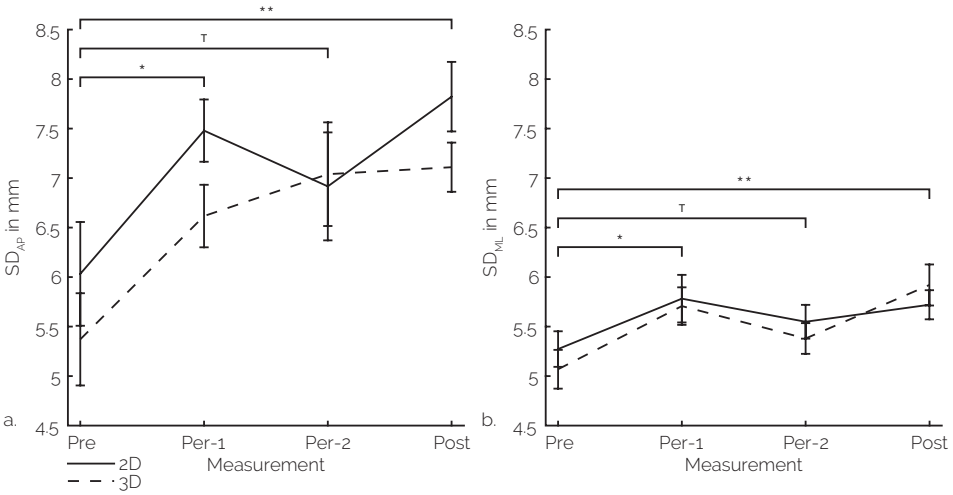

Figure 4.3. The standard deviation (SD; mm, ± SEM) in the **a.** anteroposterior (AP) direction and **b.** mediolateral (ML) direction for all moments, separate for viewing 2D (solid line) and 3D (dashed line). For both 2D and 3D and the AP and ML direction, the SD was significantly increased after all blocks of exposure (per-1, per-2, post) compared to pre-exposure. Borderline significant differences are indicated with ^{T}. Significant differences at $p < .05$ are indicated with an *. Significant differences at $p < .01$ are indicated with **.

4.3.2.2.Structural measures of postural sway

Time courses of the short-range and long-range scaling components are presented in Fig. 4.4. Repeated measures ANOVAs showed that exposure to both 2D and 3D significantly affected the short-range scaling components, $F(3, 45) = 9.42$, $p < .0001$, $\eta_p^2 = .39$ and $F(3, 45) = 10.46$, $p < .0001$, $\eta_p^2 = .41$ for AP and ML directions, respectively. Simple contrasts revealed that the α_s-AP and α_s-ML increased significantly as a result of exposure to the 2D and 3D motion stimuli (Table 4.1). As can be observed in Fig. 4.4, the α_s-ML shows a significant sharper increase between pre and per-1 and pre and post when exposed to 3D motion stimuli compared to exposure to 2D motion stimuli, resulting in a significant interaction ($F(3, 45) = 3.76$, $p < .017$, $\eta_p^2 = .20$). The long-range scaling components did not change significantly, neither in the 2D nor in the 3D session.

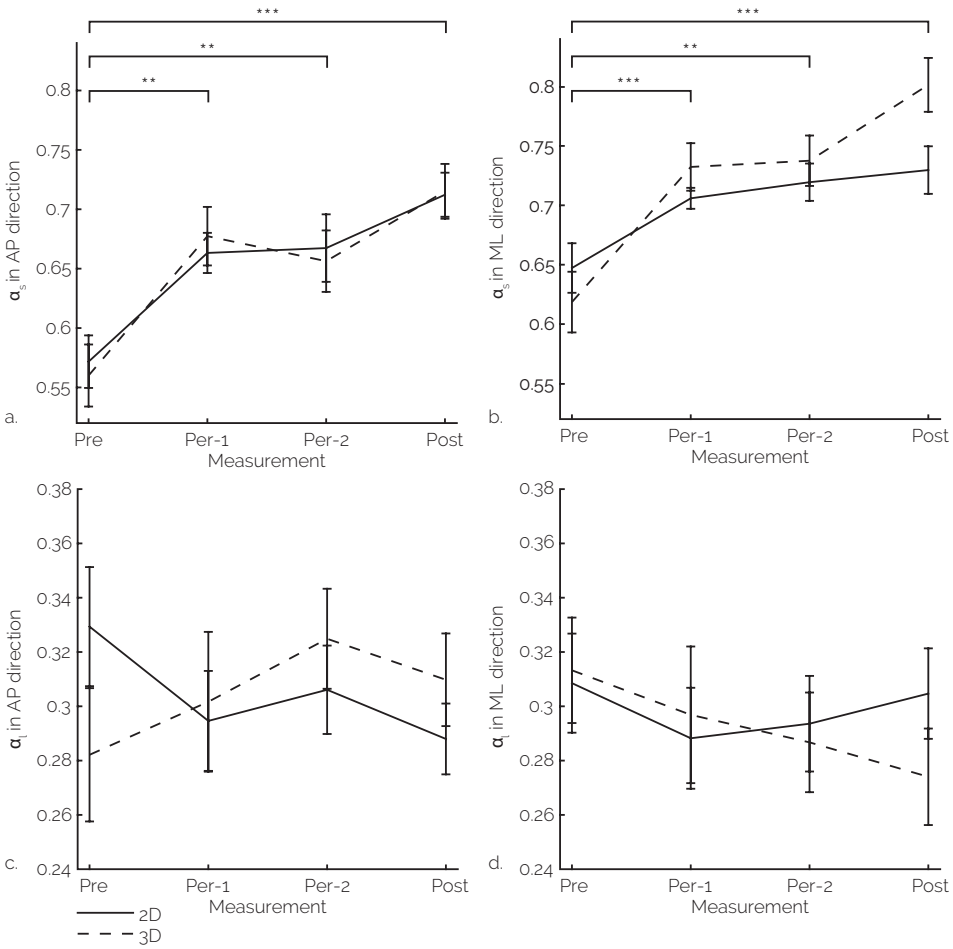

Figure 4.4. Mean (± SEM) **a.** α_s in AP direction, **b.** α_s in ML direction, **c.** α_l in AP direction and **d.** α_l in ML direction for all measurement moments, separate for viewing 2D (solid line) and 3D (dashed line). The short-term scaling components in AP and ML direction (α_s-AP and α_s-ML) for both 2D and 3D viewing were significantly increased after all blocks of exposure (per-1, per-2, post) compared to pre-exposure. Significant differences at $p < .01$ are indicated with an **. Significant differences at $p < .001$ are indicated with ***.

Table 4.1. Simple contrasts following RM ANOVA's on postural sway measures

Source	*df*	*F*	*p*	η_p^2
SPL				
Per-1 vs. Pre*	1	5.86	.029	.28
Per-2 vs. Pre*	1	4.87	.043	.25
Post vs. Pre***	1	15.35	.001	.51
SD AP				
Per-1 vs. Pre *	1	4.61	.049	.24
Per-2 vs. Pre ^{T}	1	4.46	.052	.23
Post vs. Pre **	1	9.58	.007	.39
SD ML				
Per-1 vs. Pre *	1	7.01	.018	.32
Per-2 vs. Pre ^{T}	1	3.67	.075	.20
Post vs. Pre **	1	9.34	.008	.39
α_s-AP				
Per-1 vs. Pre **	1	11.84	.004	.44
Per-2 vs. Pre **	1	11.74	.004	.44
Post vs. Pre ***	1	35.93	<.0001	.71
α_s-ML main effect				
Per-1 vs. Pre ***	1	19.03	.001	.56
Per-2 vs. Pre **	1	11.90	.004	.44
Post vs. Pre ***	1	16.94	.001	.53
α_s-ML interaction effect				
Per-1 vs. Pre & 3D vs. 2D*	1	6.46	.023	.30
Per-2 vs. Pre & 3D vs. 2D	1	1.37	.260	.08
Post vs. Pre & 3D vs. 2D**	1	12.56	.003	.46
Error	15			

^{T} $p < .08$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

4.4. Discussion

To our knowledge, this study is the first to compare the influence of viewing 2D and 3D motion stimuli on two potential adverse effects within one group of participants under otherwise equal conditions. Our main findings

were that exposure to both 2D and 3D motion stimuli caused equal, but moderate increases in VIMS symptoms, as measured with the SSQ, and equally affected multiple postural sway characteristics.

Confirming previous reports, this study showed that exposure to 2D and 3D motion stimuli can elicit VIMS symptoms[15,17,33,43,56,125,126], as assessed using the SSQ (for both 2D and 3D). However, we did not find evidence supporting the results from earlier studies that viewing 3D causes more VIMS compared to viewing 2D[15,17,55–57]. Both the SSQ total scores and MISC rates failed to increase substantially more in the 3D session than scores obtained in the 2D session. Moreover, we did not observe significant differences between the 2D and 3D sessions on any of the SSQ subscales. This lack of difference in VIMS scores indicates, on the other hand, that stereoscopic 3D stimuli also does not significantly decrease VIMS symptoms compared to viewing 2D stimuli; which has been suggested in the press with the development of the Oculus Rift[127].

Although we observed significant increases in VIMS symptoms, in most cases the SSQ scores reflected minor symptoms, typically other than nausea, e.g. a-specific oculomotor or disorientation symptoms (SSQ). Since we did not observe a significantly higher oculomotor score in the 3D session as compared to the 2D session, we argue that the observed oculomotor symptoms were not solely caused by the accommodation-vergence conflict[128]; but, rather reflect VIMS symptoms caused by other visual factors present in both the 2D and 3D stimuli[41,128,129]. Moreover, the observed increase in disorienting symptoms, which are only part of the symptom set of VIMS, provides evidence in favour of VIMS over visual discomfort. Finally, the results on the SSQ are in line with the only two other studies that investigated VIMS in relation to viewing 2D and 3D motion stimuli on a TV screen[17,56]. However, the severity of VIMS was very low compared to that observed in studies using (large) projection screens, as used in movie theatres[33,35,47,55].

The choice of the documentary in relation to the size of the TV-screen may explain the marginal increase in VIMS symptoms in our study. Since the documentary was originally designed to be displayed on cinema screens, it contains several geometrical distortions when shown on a smaller screen[130,131]. By displaying the documentary on a significantly smaller screen, the interaxial distance of the stereo camera was scaled down too. The down scaling caused geometrical distortions, since the viewer's pupil distance is fixed, i.e. does not scale down. In addition, by showing this documentary on a TV screen a large difference between the viewing angle subtended by the TV screen and the viewing angle captured by the camera was introduced (previously also referred to as external and internal fields of view)[35,47]. It has been shown that a large discrepancy between these viewing angles can reduce VIMS[35,47]. Summarized, both factors may have decreased the naturalness of the images to such an extent that the images were judged as somewhat unnatural, reducing VIMS. As proposed by Golding et al. and

Gresty et al.[107,132], visual cues that are obviously incongruent to other (i.e. vestibular and expected) cues are set aside by the central nervous system, i.e. the visual cues are "quarantined". This quarantining of the visual cues thus suppressed the sensory conflict between the sensed and expected sensory cues, and led in the 3D condition to less VIMS than hypothesized. Further research would help to obtain a better insight into which visual factors motivate the central nervous system to quarantine visual cues. Such an insight is not only valuable from a fundamental point of view, but also would serve a practical purpose. If visual factors are defined that stimulate quarantining, such factors can be incorporated (or left out) in visual motion stimuli to reduce (or increase) VIMS. As discussed above, we propose that at least two visual factors, present in the stimulus used in this study, may have caused quarantining: 1) geometrical distortions provoked by showing the documentary on a smaller screen compared to where it was designed for, and 2) the difference between the viewing angle captured by the camera and the viewing angle subtended by the TV screen[35,47]. However, future research – typically requiring visual motion stimuli specifically designed to optimize these discrepancies – is needed to define whether these, and possibly other factors, play a role in quarantining of the visual cues.

In this study participants only wore the polarized glasses in the 3D session, which could be a confounding factor. Read et al.[17], found that participants who thought they were watching 3D motion stimuli, but were actually viewing 2D stimuli through polarized or shutter-glasses, already reported more VIMS symptoms than participants who knew they were watching 2D. It was suggested that part of the increase in VIMS symptom severity could be accounted for by these glasses and the conviction that viewing 3D causes adverse effects, and not by the 3D stereoscopic depth cues as such[17]. However, in this study we did not find a difference between VIMS symptoms caused by viewing 2D stimuli and 3D stimuli, excluding the possibility that the polarized glasses had a significant confounding influence on VIMS symptoms.

With regard to postural sway we expected that viewing 2D and 3D motion stimuli would cause a significant increase, and we tested whether 3D stimuli would cause more postural sway compared to 2D stimuli. Indeed we found significant increases in postural sway after viewing both 2D and 3D, but 3D stimuli did not cause more postural sway than 2D. The global postural sway characteristics showed that participants swayed more and further in both the fore-after and left-right directions after viewing 2D and 3D motion stimuli. Moreover, the structural characteristics showed that postural sway became more persistent on a short time scale (0.3-0.8 s) due to exposure to 2D and 3D motion stimuli. In other words, viewing 2D and 3D motion stimuli made it more likely that the CoP velocity continued with similar characteristics, i.e. with the same direction and speed, as it did in the (very recent) past.

Earlier studies reported similar increases on postural sway effects

of 2D and 3D motion stimuli, however, in separate studies ([21,34,35,54,121] versus [33], respectively). With this study we were able to compare postural sway caused by viewing 2D and 3D motion stimuli in one single study, and observed that exposure to 3D motion stimuli did not cause more postural sway compared to viewing 2D. This finding is in agreement with yet another recent study[49] in which similar increases in postural sway measures were observed induced by viewing still- and motion images. Together, these studies show that postural sway obtained with eyes closed can be affected by watching stimuli per se, and does not necessarily depend on the type of stimuli watched. This observation may be explained by so-called exploratory postural behaviour of an endogenous nature[27,133,134], rather than an exogenously caused postural sway as can be observed while watching visual motion. An increased postural sway during exposure to the motion stimuli could thus allow the participant to gain more information about self-orientation with respect to the virtual environment[134].

In summary we conclude that we can be equally moved by and do not really get sick from viewing 2D and 3D motion stimuli designed for a cinema environment on a commonly available TV screen, in which case quarantining is at issue.