Exploring Behavioral Methods to Reduce Visually Induced Motion Sickness in Virtual Environments

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Abstract. The use of Virtual Environments (VE) is continuously growing and is becoming more important for research, rehabilitation, and entertainment. Unfortunately, visually induced motion sickness (VIMS) is still a major issue and a common side-effect of VEs. The symptom cluster of VIMS is multifaceted and can include oculomotor issues, fatigue, disorientation, dizziness, and/or nausea. Over the past decades, several different remedies for VIMS have been introduced and tested with mixed results. The present paper will summarize some of the most promising countermeasures, with a particular focus on behavioral techniques. This will include a discussion of adaptation and training, postural stability, and factors that make a VE experience more pleasant. Despite the existence and the success of some of these methods, it is highly desirable to continue exploring techniques that will ultimately guarantee the well-being and safety of VE users in the future.

Keywords: Simulator sickness · Motion sickness · Vection · Prevention · Countermeasures · Sensory conflict · Postural stability

1 Introduction

Visually induced motion sickness (VIMS) is a specific form of traditional motion sickness and can occur in users of Virtual Environments (VEs), such as in driving or flight simulators or during video games (see [1], for an overview). Typical symptoms can range from pallor, fatigue, cold sweat, and oculomotor issues to disorientation, dizziness, nausea, and/or vomiting. In contrast to traditional motion sickness, physical movement is often absent or limited during VIMS, instead, symptoms are typically caused by visual stimulation.

The genesis of VIMS is not fully understood yet and several different theories try to explain this sensation. Two of the most prominent theories of VIMS involve sensory conflict and the role of postural control. The *sensory conflict theory* [2, 3] proposes that VIMS is caused by a mismatch between or within the visual, vestibular, and somatosensory senses. In other words, VIMS arises in situations when the information delivered by these senses is not in accordance with each other. In the case of VEs, the visual stimulation can—if it is compelling enough—generate the sensation of self-motion (so-called vection; for overviews see [4, 5]), although the VE user typically remains stationary. In contrast, the vestibular and somatosensory senses signal stasis, resulting

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in a visual-vestibular/somatosensory conflict. According to the sensory conflict theory, this mismatch can result in VIMS if it is novel to the user and successful coping or adaptation strategies have not yet been established by the organism. In contrast, the *postural instability hypothesis* [6, 7] proposes that VIMS occurs in situations in which the ability to control ones posture is challenged and/or reduced. That is, visual stimulation in VEs can cause changes in postural sway (defined as small involuntary displacements of the body) which in turn has been shown to be linked to VIMS. For instance, Stoffregen and colleagues [8] have observed changes in postural sway in participants who later reported to be motion sick. However, both the sensory conflict theory and the postural instability theory have their strengths and weaknesses (see [1], for a discussion) and a final evaluation is, at this stage, not possible.

Despite the lack of theoretical understanding of VIMS as a whole, it is highly desirable to develop successful countermeasures to prevent (or at least minimize) VIMS. The prevalence of VIMS has been estimated to range from 5 % to 60 % of VE users [9], depending on the setup of the VE system and the task that is used. Given that VE systems are now easily accessible to everyone (e.g., through affordable head-mounted devices such as Oculus Rift, Google Cardboard, HTC Vive etc.) and are becoming more and more popular, even a small fraction of the above mentioned estimations might result in a substantial number of users who are at risk of suffering from VIMS. From a marketing point of view, this number is doubtlessly troublesome, as it might hamper the acceptance of VE systems at large. But more importantly, VE systems are not only used for entertainment purposes, but are gaining more importance in the context of rehabilitation and research. For instance, driving simulators are a highly valuable and commonly used tool to train and assess driving performance following serious illness or injuries (e.g., stroke, traumatic brain injury etc.), as these patient populations cannot be safely trained and tested with real on-road driving. Therefore, it is not tolerable that the application and success of driving simulators is jeopardized by the occurrence of VIMS.

In the past, a variety of techniques trying to reduce VIMS has been introduced (for overviews see [1, 10]). In the following sections, I will summarize some of these techniques, with a particular focus on *behavioral methods* that I have personally used to counteract VIMS. To begin with, however, I will briefly discuss the use of anti-motion sickness medication (and explain why they are not useful with respect to VIMS), before I will continue with a description of selected behavioral methods to reduce VIMS. Note that the present paper is not meant to be an exhaustive review of all existing countermeasures, but rather it focuses on those techniques that showed promising results within my own realm of research.

2 Medication and Naturopathic Approaches

Medical countermeasures are often the method of choice to cope with traditional motion sickness when travelling. Anti-sickness drugs are often available over-the-counter and typically offer rapid relief. Various drugs have been previously tested, including antihistamines (e.g., meclozine, cyclizine) and anti-cholinergics (e.g., scopolamine) (see [11, 12], for overviews). Although these drugs have been shown to successfully reduce traditional motion sickness and can also provide relief from VIMS to some extent [3, 13], most of these medications can lead to serious side-effects such as dizziness, fatigue, or impaired cognitive functions. Consequently, the applicability of medical drugs with respect to VIMS is highly limited. Drowsiness, for instance, may be a tolerable side-effect for passengers of long overnight flights, but not so for the pilots who are being trained in a flight simulator and for whom unimpaired mental capacities are a necessity. In most cases when VEs are used, the side-effects related with anti-sickness medication are unacceptable, making these drugs impractical for VEs.

In addition to classic anti-sickness medications, several ingestible, inhalable, or alternative medical approaches not classified as drugs have been investigated to counteract traditional motion sickness and VIMS. For instance, ginger is frequently referred to as being an effective anti-motion sickness agent and companies promise relief from VIMS after the intake of ginger-based pills. However, evidence for the efficacy of ginger during controlled experimentation is limited and the few studies that have been conducted revealed mixed findings [14, 15].

3 Behavioral Countermeasures

To prevent the undesirable side-effects caused by anti-sickness medications, a variety of behavioral countermeasures against VIMS has been introduced in the past. Among others, technical modifications can reduce the risk of VIMS, such as reducing the visual field-of-view [16, 17], minimizing the time-lag between actions performed in the VE and the visual and/or motion responses [18, 19], or reducing the use of Head Mounted Displays [20]. However, some of these modifications are not feasible. Reducing the field-of-view, for example, might be a reasonable solution at home (i.e., moving farther away from the TV or computer screen), but it is not an acceptable solution for driving or flight simulators that aim to provide an immersive virtual experience and want to create a strong sense of presence or vection. Consequently, other behavioral countermeasures that do not interfere with the technical aspects and the VE experience are needed. Some promising techniques have been already explored and will be discussed next.

3.1 Adaptation and Training

One of the most efficient techniques to minimize and prevent VIMS is arguably *adaptation*. As mentioned earlier, the sensory conflict theory of motion sickness proposes that VIMS is not only rooted in a sensory conflict, but rather occurs when the organism has not yet established coping strategies to deal with these sensory incongruences. Consequently, repeated exposure to the same stimulus that initially caused VIMS in the first place should result in reduced VIMS after a while. Indeed, several studies found that adaptation is a successful mechanism to minimize VIMS [21–23]. For instance, Hill and Howarth [24] had their participants play a 20-min video game over the course of five consecutive days and measured sickness severity. VIMS significantly decreased after each gaming session and was reduced to a minimum after the 5th experimental day. Although repeated exposure has been shown to be successful in preventing VIMS, it can be time-consuming, resource-intensive, and requires a high amount of dedication. Consequently, adaptation might not always be feasible as the method of choice to cope with VIMS despite its success.

Another coping strategy could potentially be *training*. As noted above, adaptation typically requires repeated exposure to the exact same nauseating stimulus to allow the organism to successfully adapt over time. Training, in contrast, does not underlie this restriction; a separate, different (and probably less complex) VE setup could be used to train VE users to cope with VIMS before they are exposed to the actual task-relevant VE. Supporting evidence for this assumption was found in one of my recent studies (in preparation), where a link between video game experience and VIMS was discovered. In that study, participants were asked to perform a simulated driving task using a commercial console video game on a large projection screen. None of the participants was familiar with the video game that was used. Interestingly, those participants who at least sometimes played video games at home (irrespective of the type of game), reported less sickness compared to those who never played video games at all (see [25] for similar findings). This suggests that video game experience might have a protective effect on the occurrence of VIMS and, consequently, that video games could be used as a training tool to reduce it. However, further systematic experimentation is needed to further elaborate on this initial finding.

3.2 Supporting Postural Stability

According to the postural instability theory of motion sickness [6], VIMS is not caused by a sensory conflict per se, but is primarily elicited in situations that challenge maintaining one's postural stability (with postural stability defined as minimizing uncontrolled body movements). Previous studies have shown that changes in postural stability (i.e., decreased or increased postural sway) are associated with or even precede VIMS [8, 26]. Consequently, increasing postural stability should result in a reduction of VIMS. In fact, several studies investigated the efficacy of passive restraint against VIMS (e.g., by fixating the participants' bodies to a rigid surface), unfortunately with mixed results [27–29]. In a study that demonstrated a positive effect of passive restraint, Chang et al. [30] asked standing participants to play a console video game that generated VIMS. Half of the participants were passively restrained using elastic straps, whereas the other half was not restrained and stood freely during gameplay. Results showed that those participants who were passively restrained reported significantly less VIMS compared to the unrestrained participants. Recently, Keshavarz et al. [31] exposed younger and older participants to a driving video game for 25 min in two test sessions. In one session, participants' torso and head were restricted to a back- and headrest using elastic straps. In the other session, participants were not restrained and the back- and headrest were removed. VIMS was continuously recorded in both tests sessions. An overall difference between the unrestrained and restrained condition did not emerge, however, some participants indeed benefited from passive restrained. That is, older adults who became sick when playing the driving game without restraint, reported less VIMS when their bodies were fixated with the straps. Interestingly, this effect was only observed in the older adults, who are known to have generally reduced postural stability due to age-related changes, but it did not show for younger adults. Thus, passive restraint can—under certain circumstances and in certain populations—indeed minimize VIMS. Nevertheless, note that passive restraint might bear issues that might limit its applicability, such as fostering anxiety in some users. Also, active and unrestricted movement can be essential for some VE applications and therefore preventing such movements is not an option.

3.3 Promoting a Pleasant Ambience

In a set of multiple studies, [32–34] demonstrated that VIMS can be successfully reduced by pleasant music, pleasant odors, and constant airflow. In all of these studies, participants were exposed to a 15 min long video on a large screen showing a bicycle ride that was shot from a first-person point of view. While watching the video, participants were continuously monitored and reported their level of VIMS using the Fast Motion Sickness Scale, a verbal self-rating scale particularly designed to measure VIMS [35].

In the first of the three studies [32], participants were randomly assigned to four groups: the first group was provided with relaxing music while watching the video, the second group listened to neutral pop music, the third group to stressful music, and the fourth group was not provided with any music. After stimulus presentation, participants were asked to rate the pleasantness of the music that they were exposed to. Results showed that music that was perceived as pleasant—regardless whether the music was of relaxing, neutral, or stressful nature—successfully alleviated VIMS. In other words, participants who perceived the music as being pleasant reported less VIMS compared to the control group and to the groups who rated the music as unpleasant. Currently, a follow-up study is being conducted to further investigate the mechanisms underlying this effect, aiming to determine the role of the music's valence and arousal level with respect to reducing VIMS (in preparation). In contrast to pleasant music, background sound matching the visual scene (i.e., street noise produced by pedestrians or cars) does typically not reduce VIMS [36, 37].

In the second study [33], two different odors (leather as aversive scent and rose as pleasing scent) were chosen and provided to the participant while they watched the same video of the bicycle ride. Similar results compared to the music study mentioned above were found. Again, the odor that was perceived as pleasant (regardless of whether it was leather or rose) significantly reduced VIMS, whereas the unpleasant odor did not affect the level of VIMS.

Finally, in the third study [34], one group of participants was provided with constant airflow that was produced by two stationary fans that were positioned alongside the large projection screen while being exposed to the bicycle video. A second group acted as control group and did not receive airflow. Results showed that the group that was provided with airflow reported significantly less VIMS compared to the control group, suggesting that keeping a laboratory air-conditioned and providing sufficient airflow can be an effective, simple, and affordable way to minimize VIMS.

In a nutshell, all treatments used in the three studies reduced VIMS to a similar extent. However, the reason for the positive effect of pleasant music, pleasant odors, and airflow remains speculative, as none of the current theories of VIMS can sufficiently explain why and how VIMS should be reduced by these countermeasures. Distraction might come to mind first, but if pure distraction was the key, then music and odors in general should reduce VIMS, and not only music and odors that were perceived as pleasant. An alternative explanation could be that creating a pleasant ambience might interfere and conflict with the negative sensation of VIMS, which in turn might not allow VIMS to fully unfold. If this is the case, other methods that further facilitate the pleasantness of the VE ambience should have similar (or even enhancing) effects.

3.4 Alternative Potential Remedies

Gaze stabilization. Adding a stable fixation point to the center of the visual screen has been demonstrated to reduce VIMS [38, 39]. In fact, developers of commercial video games now sometimes superimpose a small transparent circle on top of the visual screen to reduce VIMS (e.g., *Mirror's Edge* by EA Digital Illusions Creative Entertainment, see http://www.engadget.com/2008/07/17/how-mirrors-edge-fights-simulation-sickness/). This is particularly helpful in games that involve rapid and abrupt virtual camera turns (e.g., as in first-person shooting games). However, a fixation point might be an acceptable solution for video games that are designed to entertain, but it might not be for applications that are used for training, rehabilitation, and research purposes. For instance, simulated driving studies often measure natural gaze behavior using eye-tracking and a fixation point is not tolerable in this case.

Vestibular/Motion Cues. It has been noted in the past literature that providing vestibular cues in addition to visual stimulation should reduce VIMS by reducing a potential visual-vestibular conflict [40]. Unfortunately, the situation is more complex and adding vestibular/motion cues is per se not a guarantee that VIMS will diminish. As motion cues provided by any simulator are by definition not a perfect replica of real-world motion (e.g., due to limitations in motion range or due to imperfect motion algorithms), adding motion cues alone is not sufficient to decrease VIMS. Keshavarz et al. [41] recorded VIMS ratings for older and younger adults who performed a simulated driving task. Participants were assigned to two separate groups: in the first group, a fixed-base driving simulator with only visual cues was used (240° horizontal and 110° vertical curved field-of-view), whereas in the second group additional motion cues were provided (using a 6 degrees-of-freedom hexapod motion platform). Interestingly, VIMS did not significantly differ between the two groups.

In contrast, Bos [42] demonstrated that high-frequent vibration cues can reduce motion sickness. The author positioned blindfolded participants on a rotating chair and asked them to perform head movements while being rotated, a procedure known to quickly and reliably induce motion sickness. During chair rotation, participants were provided with high-frequent vibration to the head. As a result, head vibration reduced motion sickness severity by 25 %, potentially by adding noise to the vestibular system which reduced the sensory conflict. Following up on this finding, D'Amour et al. [34] tested vibration to the seat as a remedy against VIMS. While watching a VIMS-inducing video, one group of participants was provided with high-frequent seat vibration generated by a vibrating device that was attached to the bottom of the chair, whereas another group received no treatment. Although seat vibration reduced VIMS by approximately 35 %, the reduction of VIMS missed statistical significance. Nevertheless, it seems promising to further investigate the effect of vibration as a potential countermeasure against VIMS.

4 Conclusion

Visually induced motion sickness is a serious issue for the design and the use of virtual environments. To date, reliable techniques that can fully prevent VIMS are unfortunately missing, but several behavioral methods have emerged over the last decades that showed promising results. Adaptation is so far the arguably most reliable method to reduce VIMS, but it is often not feasible due to time and budget restrictions. Passively supporting postural stability can be effective for some people, but its application can be limited in some cases. Creating a pleasant ambience, on the other hand, is simple, affordable, and easily applicable, however, its reliability to reduce VIMS in different VE settings and scenarios is yet to be proven.

The decision which method is the most appropriate one to counteract VIMS should be made on a case-by-case basis, taking into account several different factors. For instance, the intended application of the VE often dictates which countermeasure is useful and which is not. In other words, some techniques such as introducing a fixation point or reducing the field-of-view can be proper methods to alleviate VIMS for video games and other entertainment devices, but they might not be in the context of research or rehabilitation. Other factors that should be taken into account often involve the available budget (e.g., is adaptation affordable?) or the targeted population (e.g., postural stability might be more effective for older users).

In sum, the technological progress over the last decades has yielded new and innovative VE trends, however, VIMS is still an issue that has not been fully solved. Optimizing existing techniques as well as exploring new options should be future goals to prevent VIMS and ultimately guarantee the well-being and safety of VE users.

References

1. Keshavarz, B., Hecht, H., Lawson, B.D.: Visually induced motion sickness: Characteristics, causes, and countermeasures. In: Hale, K.S., Stanney, K.M. (eds.) Handbook of Virtual Environments: Design, Implementation, and Applications, pp. 648–697. CRC Press, Boca Raton, FL (2014)
2. Oman, C.M.: Motion sickness: a synthesis and evaluation of the sensory conflict theory. Can. J. Physiol. Pharmacol. **68**, 294–303 (1990)
3. Reason, J.T., Brand, J.J.: Motion Sickness. Academic Press, New York (1975)
4. Hettinger, L.J., Schmidt, T., Jones, D.L., Keshavarz, B.: Illusory self-motion in virtual environments. In: Hale, K.S., Stanney, K.M. (eds.) Handbook of Virtual Environments: Design, Implementation, and Applications, pp. 435–466. CRC Press (2014)
5. Keshavarz, B., Riecke, B.E., Hettinger, L.J., Campos, J.L.: Vection and visually induced motion sickness: how are they related? Front Psychol. **6**, 472 (2015)

6. Riccio, G.E., Stoffregen, T.A.: An ecological theory of motion sickness and postural instability. Ecol. Psychol. **3**, 195–240 (1991)
7. Stoffregen, T.A., Riccio, G.E.: An ecological critique of the sensory conflict theory of motion sickness. Ecol. Psychol. **3**, 159–194 (1991)
8. Smart Jr, L.J., Stoffregen, T.A., Bardy, B.G.: Visually induced motion sickness predicted by postural instability. Hum. Factors **44**, 451–465 (2002)
9. Kennedy, R.S., Drexler, J., Kennedy, R.C.: Research in visually induced motion sickness. Appl. Ergon. **41**, 494–503 (2010)
10. Golding, J.F., Gresty, M.A.: Pathophysiology and treatment of motion sickness. Curr. Opin. Neurol. **28**, 83–88 (2015)
11. Sherman, C.R.: Motion sickness: review of causes and preventive strategies. J. Travel Med. **9**, 251–256 (2002)
12. Shupak, A., Gordon, C.R.: Motion sickness: advances in pathogenesis, prediction, prevention, and treatment. Aviat. Space Environ. Med. **77**, 1213–1223 (2006)
13. Regan, E.C., Ramsey, A.D.: The efficacy of hyoscine hydrobromide in reducing side-effects induced during immersion in virtual reality. Aviat. Space Environ. Med. **67**, 222–226 (1996)
14. Estrada, A., LeDuc, P.A., Curry, I.P., Phelps, S.E., Fuller, D.R.: Airsickness prevention in helicopter passengers. Aviat. Space Environ. Med. **78**, 408–413 (2007)
15. Lien, H.-C., Sun, W.M., Chen, Y.-H., Kim, H., Hasler, W., Owyang, C.: Effects of ginger on motion sickness and gastric slow-wave dysrhythmias induced by circular vection. Am. J. Physiol. Gastrointest. Liver Physiol. **284**, G481–G489 (2003)
16. Bos, J.E., de Vries, S.C., van Emmerik, M.L., Groen, E.L.: The effect of internal and external fields of view on visually induced motion sickness. Appl. Ergon. **41**, 516–521 (2010)
17. Keshavarz, B., Hecht, H., Zschutschke, L.: Intra-visual conflict in visually induced motion sickness. Displays **32**, 181–188 (2011)
18. Akizuki, H., Uno, A., Arai, K., Morioka, S., Ohyama, S., Nishiike, S., Tamura, K., Takeda, N.: Effects of immersion in virtual reality on postural control. Neurosci. Lett. **379**, 23–26 (2005)
19. Draper, M.H., Viirre, E.S., Furness, T.A., Gawron, V.J.: Effects of image scale and system time delay on simulator sickness within head-coupled virtual environments. Hum. Factors J. Hum. Factors Ergon Soc. **43**, 129–146 (2001)
20. Patterson, R., Winterbottom, M.D., Pierce, B.J.: Perceptual issues in the use of head-mounted visual displays. Hum. Factors **48**, 555–573 (2006)
21. Cheung, B., Hofer, K.: Desensitization to strong vestibular stimuli improves tolerance to simulated aircraft motion. Aviat. Space Environ. Med. **76**, 1099–1104 (2005)
22. Domeyer, J.E., Cassavaugh, N.D., Backs, R.W.: The use of adaptation to reduce simulator sickness in driving assessment and research. Accid. Anal. Prev. **53**, 127–132 (2013)
23. Hu, S.Q., Stern, R.M., Koch, K.L.: Effects of pre-exposures to a rotating optokinetic drum on adaptation to motion sickness. Aviat. Space Environ. Med. **62**, 53–56 (1991)
24. Hill, K., Howarth, P.: Habituation to the side effects of immersion in a virtual environment. Displays **21**, 25–30 (2000)
25. Ujike, H., Ukai, K., Nihei, K.: Survey on motion sickness-like symptoms provoked by viewing a video movie during junior high school class. Displays **29**, 81–89 (2008)
26. Stoffregen, T.A., Faugloire, E., Yoshida, K., Flanagan, M.B., Merhi, O.: Motion sickness and postural sway in console video games. Hum. Factors J. Hum. Factors Ergon. Soc. **50**, 322–331 (2008)
27. Bonnet, C.T., Faugloire, E., Riley, M.A., Bardy, B.G., Stoffregen, T.A.: Motion sickness preceded by unstable displacements of the center of pressure. Hum. Mov. Sci. **25**, 800–820 (2006)

28. Lackner, J.R., DiZio, P.: Decreased susceptibility to motion sickness during exposure to visual inversion in microgravity. Aviat. Space Environ. Med. **62**, 206–211 (1991)
29. Mills, K.L., Griffin, M.J.: Effect of seating, vision and direction of horizontal oscillation on motion sickness. Aviat. Space Environ. Med. **71**, 996–1002 (2000)
30. Chang, C.-H., Pan, W.-W., Chen, F.-C., Stoffregen, T.A.: Console video games, postural activity, and motion sickness during passive restraint. Exp. Brain Res. **229**, 235–242 (2013)
31. Keshavarz, B., Novak, A.C., Hettinger, L.J., Stoffregen, T.A., Campos, J.L.: The role of age and postural stability for visually induced motion sickness in a simulated driving task. Proc. Hum. Factors Ergon. Soc. Annu. Meet. 59, 770–770 (2015)
32. Keshavarz, B., Hecht, H.: Pleasant music as a countermeasure against visually induced motion sickness. Appl. Ergon. **45**, 521–527 (2014)
33. Keshavarz, B., Stelzmann, D., Paillard, A., Hecht, H.: Visually induced motion sickness can be alleviated by pleasant odors. Exp. Brain Res. **233**, 1353–1364 (2015)
34. D'Amour, S., Campos, J.L., Keshavarz, B.: The efficacy of airflow and seat vibration on reducing visually induced motion sickness. In: Lake Ontario Visionary Conference (L.O.V.E.), Niagara Falls, ON (2016)
35. Keshavarz, B., Hecht, H.: Validating an efficient method to quantify motion sickness. Hum. Factors J. Hum. Factors Ergon. Soc. **53**, 415–426 (2011)
36. Keshavarz, B., Hecht, H.: Stereoscopic viewing enhances visually induced motion sickness but sound does not. Presence **21**, 213–228 (2012)
37. Keshavarz, B., Hecht, H.: Visually induced motion sickness and presence in videogames: The role of sound. Proc. Hum. Factors Ergon Soc. Annu. Meet. **56**, 1763–1767 (2012)
38. Webb, N.A., Griffin, M.J.: Optokinetic stimuli: motion sickness, visual acuity, and eye movements. Aviat. Space Environ. Med. **73**, 351–358 (2002)
39. Yang, J.X., Guo, C.T., So, R.H.Y., Cheung, R.T.F.: Effects of eye fixation on visually induced motion sickness are they caused by changes in retinal slip velocity? proc. Hum. Factors Ergon. Soc. Annu. Meet. **55**, 1220–1224 (2011)
40. Curry, R., Artz, B., Cathey, L., Grant, P., Greenberg, J.: Kennedy SSQ results: fixed vs. motion-base ford simulators. In: Proceedings of the Driving Simulation Conference Europe 2002, pp. 289–300 (2002)
41. Keshavarz, B., Ramkhalawansingh, R., Haycock, B., Shahab, S., Campos, J.L.: The role of multisensory inputs on simulator sickness in younger and older adults during a simulated driving task. In: Proceedings of the Driving Simulation Conference Europe 2015, Tuebingen, Germany, pp. 239–240 (2015)
42. Bos, J.E.: Less sickness with more motion and/or mental distraction. J. Vestib. Res. Equilib. Orientat. **25**, 23–33 (2015)