Is Virtual Reality Sickness Elicited by Illusory Motion Affected by Gender and Prior Video Gaming Experience?

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ABSTRACT

Gaming using VR headsets is becoming increasingly popular; however, these displays can cause VR sickness. To investigate the effects of gender and gamer type on VR sickness motion illusions are used as stimuli, being a novel method of inducing the perception of motion whilst minimising the "accommodation vergence conflict". Females and those who do not play action games experienced more severe VR sickness symptoms compared to males and experienced action gamers. The interaction of the gender and gamer type revealed that prior video gaming experience was beneficial for females, however, for males, it did not show the same positive effects.

Index Terms: Virtual Reality—Fraser Wilcox Illusions—VR Sickness—Discomfort; Head movements—Gender—Adaptation—Habituation

1 Introduction

Virtual Reality (VR) headsets have made their way into mainstream gaming, with recent titles like *Half Life Alyx* (Valve, 2020) attracting many players. However, the use of head mounted displays (HMDs) can also cause VR sickness (cybersickness) [9, 13], potentially limiting play time. VR sickness experienced when using HMDs can be caused by various factors, and can lead to symptoms similar to motion sickness, such as nausea, dizziness and disorientation, and to visual stress symptoms, such as headache, eye strain or difficulty focusing [9, 13]. Some individuals seem to be more prone to experience these symptoms, and in extreme cases the individual cannot use VR at all without experiencing VR sickness, potentially limiting wider uptake, and the commercial success of VR applications.

Two main causes of VR sickness are the *accommodation-vergence conflict* (e.g. [6, 10]), which is a conflict within the visual focusing system, and the conflict between the visual and the vestibular system (e.g. [1]). VR sickness caused by the latter is often accompanied by postural instability and "sway" (e.g. [1]). Studying these two causes separately is important in understanding how to mitigate their effects; however, finding stimuli which enable this is not as straightforward. In this study we take a novel approach by using optimised Fraser Wilcox illusions to study sickness caused by perceived motion. These illusions are 2D stationary images that, due to their patterns, are perceived as moving (see figure 1), and may therefore be used to stimulate feelings of VR sickness associated with motion. However, they do not actually move through the virtual environment coordinate system, and so minimise discomfort caused by constant change in discrepancy between accommodation and vergence.

We seek to investigate two factors that might help explain individual differences in the experience of VR sickness: gender and time spent playing action video games. Research suggests that females experience more VR sickness and sway than their male counterparts [11, 12, 14] and that motion sickness can be decreased with repeated exposure to a sickness-inducing environment [3, 5, 8]. Habituation to motion sickness has been shown when an individual is repeatedly exposed to the same sickness-inducing virtual (or real) environment. However, in our case we are interested whether these adaptation effects also occur between different virtual environments. More precisely, whether individuals who spend a large amount of time playing action video games (not using VR headsets) build up habituation effects which translate to VR. Thus, our study investigates the effects of gender and action video gaming experience on VR sickness and postural sway caused by perceived motion (using Fraser Wilcox illusions as visual stimuli) in HMDs.

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2 Study Design

43 participants with normal or corrected to normal vision took part, ranging in age from 19 - 39 years (M= 21.00 years, SD= 4.17). Twenty two participants classified as AVGPs (15 males, 7 females) and 21 as NVGPs (4 males, 17 females). Participants were asked to report the gender they identified as rather than their biological sex, with a limitation of this study being the unequal distribution of gender in the in the two gaming groups.

A Valve Index headset was used to present the stimuli which consist of 4 circular optimized Fraser Wilcox illusions, each being made up by 8 rings containing patterns with gradient luminance profiles (black to dark grey and white to light grey), as shown in figure 1. The illusions were presented in the centre of the visual field.

Participants were categorised as AVGPs and NVGPS according to the criteria of the Video Game Playing Questionnaire created by the Bavelier lab [2]. Head movements of standing participants were recorded using the measured headset position, to identify possible medio-lateral or anterior-posterior swaying induced by stimulus presentation. Prior to the VR experiment participants played a short VR game (Spiderman, 5-10min) which could have contributed to the VR sickness experienced by the participants.The VR experiment consisted of two parts: a training phase, and the experimental trial. In the experimental trial, illusions were presented for 90 seconds. VR sickness was measured using the SSQ [7] and susceptibility to motion sickness was measured using the Motion Sickness Susceptibility Questionnaire Short Version (MSSQ-Short) [4].

3 Results

3.1 VR Sickness

MSSQ and SSQ scores were predicted using linear models.

Females scored higher on the MSSQ ($F(1,1028) = 90.51$, $p<.001$, $\Delta BIC = 81.18$) and SSQ ($F(1,1028) = 111.99$, $p<.001$, $\Delta BIC = 141.11$) compared to males.

NVGPs scored higher on the MSSQ ($F(1,1028) = 44.54$, $p<.001$, $\Delta BIC = 114.24$) and SSQ ($F(1,1028) = 27.02$, $p<.001$, $\Delta BIC = 157.25$) compared to AVGPs.

A significant interaction of gamer type and gender was found for MSSQ ($F(1,1028) = 8.68$, $p = .003$, $\Delta BIC = 1.74$) and SSQ ($F(1,1028) = 54.60$, $p<.001$, $\Delta BIC = 46.46$) scores.

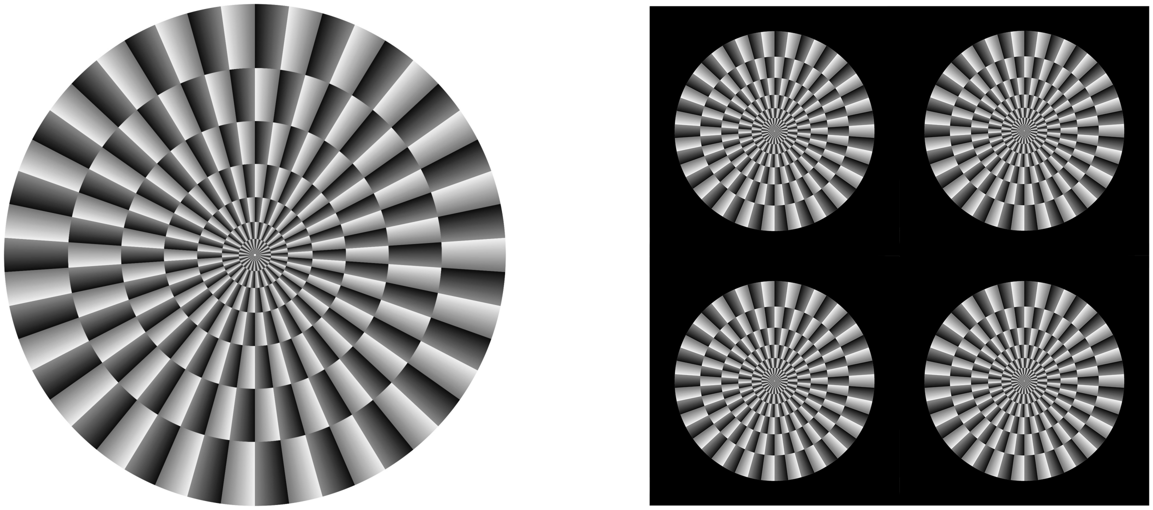

Figure 1: Example of a rotating optimised Fraser Wilcox illusion (left) and the corresponding stimulus used in this study (right)

3.2 Head Movements

Head movements were predicted using linear mixed effect models. No difference in medio-lateral ($F(1, 39) = 0.45$, $p = .508$) or anterior-posterior ($F(1, 39) = 2.20$, $p = .146$) head movements was found between genders.
No differences were found for head movements between NVGPs and AVGPs in the in the medio-lateral ($F(1,39) = 3.77$, $p = .059$) or anterior-posterior direction ($F(1, 39) = 1.89$, $p = .178$).
The interaction of gamer type and gender had no effect on head movements in the medio-lateral ($F(1, 39) = 0.27$, $p = .604$) or anterior-posterior direction ($F(1, 39) = 0.49$, $p = .488$).

4 Conclusion

Gender and video gaming experience can affect VR sickness induced by apparent motion stimuli. Females and NVGPs experienced significantly more VR sickness in this study compared to males and AVGPs and rated their motion sickness susceptibility higher compared to males and AVGPs (MSSQ). Neither gender nor prior video gaming experience had an effect on the magnitude of head movements elicited by participants throughout the experiment. The motion signals perceived by the illusions in this study might not have been strong enough to elicit head movements related to the visual stimulus. Also, prior gaming experience seemed to have a positive adaptation effect on females, but the opposite effect on males. Female AVGPs experienced less VR sickness compared to female NVGPs whereas male AVGPs tended to experience more symptoms compared to male NVGPs.

This interaction between gender and gamer type would suggest that various additional factors could also influence the experience of VR sickness, such as the type of virtual environment that is presented. This makes it hard to decide how to best design a virtual environment to make it accessible to everyone. Training individuals first, using less sickness-inducing environments, before immersing them into a complex virtual environment in VR may be an effective method in reducing adverse symptoms. However, a less time-consuming method for the user would be the option of differing settings within VR games allowing the player to choose a less sickness inducing option in game play, for example by reducing the FOV or the speed the game is played at. In addition, optimised Fraser Wilcox illusions are recommended as stimuli for the investigation of VR sickness caused by conflicts between the sensory systems as they minimise the effect of the accommodation vergence conflict.

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