An experimental methodology to capture user and gameplay data tied to cybersickness

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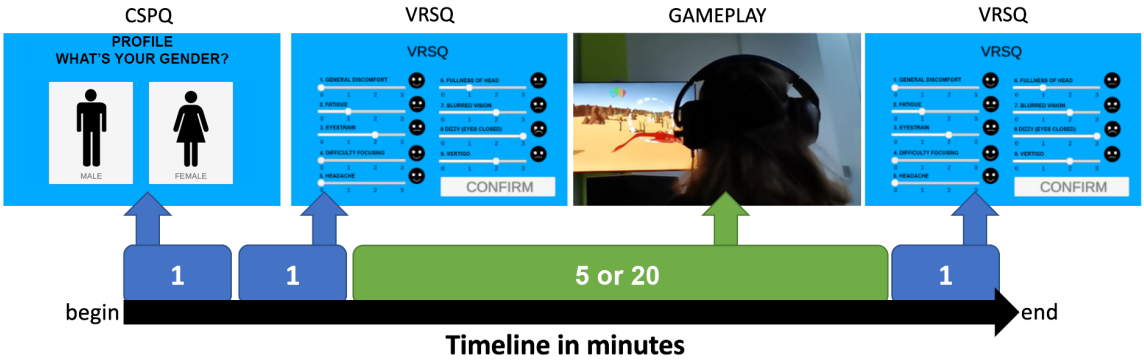

Fig. 1. The experience begins with the participants filling the Cybersickness Profile Questionnaire (CSPQ), followed by the VRSQ. Next, participants play the game for 5 (or 20) minutes. Finally, they fill a post-VRSQ questionnaire.

Virtual reality (VR) and head-mounted displays are constantly gaining popularity in various fields such as education, military, entertainment, and bio/medical informatics. Although such technologies provide a high sense of immersion, they can also trigger symptoms of discomfort. This condition is called cybersickness (CS) and is quite popular in recent publications in the virtual reality context. We created and conducted an iterative evaluating protocol methodology and proposed two VR games (a racing game and a flight game). The recorded data can be used for further machine learning analysis tied to cybersickness.

CCS Concepts: • **Human-centered computing** → **Virtual reality**.

Additional Key Words and Phrases: virtual reality, head mounted displays, cybersickness, data collection, games

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1 INTRODUCTION

Head-mounted displays (HMDs) are one of the means of achieving immersive virtual reality environments. These devices usually consist of electronic displays and lenses that are fixed over the head where the display and lenses face

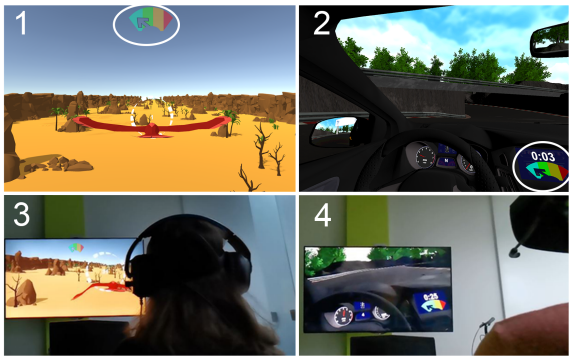

Fig. 2. Participants playing the flight game at the left (1 and 3) and the race game at the right (2 and 4). In images 1 and 2, it is possible to see a visual feedback of their current discomfort level, marked with a circle.

the eyes of the user. HMDs are used for various purposes in the industry such as in games that focus on entertainment [12], military [11], education [1], therapy [3] and simulators for numerous contexts [7].

Unfortunately, HMDs are strongly related to frequent manifestations of discomfort [6]. Among the possible manifestations, cybersickness (CS) deserves special attention as it is the most frequent and is usually associated to long exposures to HMDs.

2 MATERIALS AND METHODS

Two different games were created for this work: (1) a race game and (2) a flight game as shown in Figure 2. In our protocol, we require the participants to fill in questionnaires before and after participating in a 5 or 20 minutes VR game session of our games.

In the race game interaction, the acceleration varies according to the choice of the user (they push the acceleration according to their will). In contrast, the flight game simulates an almost-constant acceleration. The player experience with both games is detailed in Figure 1.

The data collection occurred in a few different places such as schools, universities, and technological events. We spent a total of tree months collecting data with two HMD devices (HTC Vive and Oculus Rift). All participants agreed with their anonymous participation in the study and signed consent forms. The participants were allowed to quit the experiment whenever they wanted.

2.1 Data visualization

We build a data visualization application using Unity 3D. This application read our recorded dataset in CSV format and create graphical visualizations using position and discomfort attributes from data acquired in our protocols.

3 GENDER DIFFERENCES ANALYSIS

In this analysis, we used 3993 samples from race game recorded data. We observed that the occurrence of the discomfort reported by individuals occurs throughout the track (Figure 3) using position and discomfort level data presented in Table 1. However, the discomfort levels in specifics regions of track have a more significant accumulation.

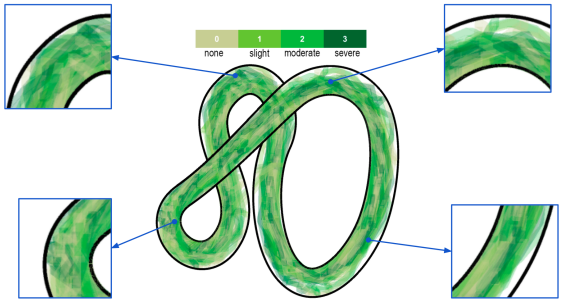

Fig. 3. Visualization of all moments where the participants of the elapsed game reported some of the levels of discomfort during the experiment. In the image, the intensity of discomfort reported by users varies from 0 (none) to 3 (severe) represented by the legend colors

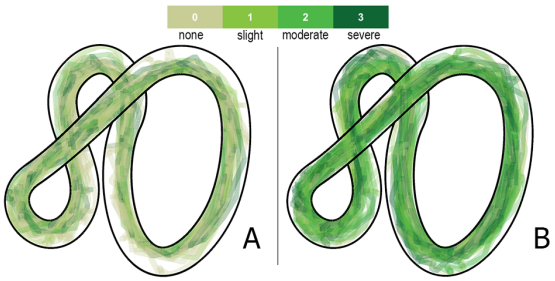

Fig. 4. comparative of the discomfort reported by female and male participants. In the image, the intensities of discomfort reported by users vary from 0 (none) to 3 (severe) represented by the legend colors.

In a comparative sample of reports of discomfort between individuals of the female gender (7 females with 1772 samples) and male (8 males with 2221 samples), We observed that in an accumulated result, the male participants reported discomfort values greater than zero more often than individuals of the female gender (illustrated in Figure 4).

Biocca [2] and Kolasinski [6], who report those female individuals are more susceptible to symptoms of MS. Despite being similar diseases, they have different environments and manifestations. Because of this, for this case, there is no way to say if there is a difference between genders for the manifestation of CS-based only on Biocca [2] and Kolasinski [6] works cited in this thesis. However, in this specific testing stage, the race track analysis results showed that the female audience reported less discomfort than the male audience.

Furthermore, we checked men participants performed the race game more competitively than women during the experiment, alternating acceleration shift frequency, and even crashing into track's corners. On the other hand, women played with near-constant acceleration shift frequencies avoiding collisions.

Additionally, Curry et al. [4] conducted a similar experiment. They examined (with SSQ) the influence of gender susceptibility and vehicle control on discomfort in two different VR experience tasks, where participants played (as vehicle driver) or viewed (as vehicle passenger) the game for up to 15 minutes. They also verified who had discontinued early in these experiences. Concerning MS incidences, the authors found no MS discrepancies among the participant's gender or groups (drivers and passengers). On the other hand, according to the authors, females participants discontinued early because of discomfort. In other words, the VR exposure time for female participants was significantly less than for

Table 1. Raw feature set captured in Protocols 5 and 6, which contains numerical (N) and categorial (C) features.

Preliminary Feature set			
Gameplay data		Users data	
Feature	Type	Feature	Type
Time Stamp	N	Gender	C
Speed	N	Age	C
Acceleration	N	VR Experience	C
Rotation (x, y and z)	N	Flicker sensitivity	C
Position (x, y and z)	N	Pre-symptoms	C
Region Of Interest	C	Glasses wearing	C
Size of FOV	N	Vision Impairments	C
Frame Rate	N	Posture	C
Static Frame	C	Dominant Eye	C
Haptic Feedback	C	Discomfort Level	N
Degree of Control	C		
DoF Simulation	C		
Player Locomotion	C		
Automatic Camera	C		

male participants. Moreover, the authors were limited to 2 tasks and not deeply explored other virtual reality tasks associated with virtual reality discomfort.

According to recent studies [4, 5, 8], female individuals experienced better performance or magnified cognitive skills, localization, and picture tasks in VR than males. These results corroborate and suggest that gender differences in cybersickness may change besides different tasks in virtual reality environments.

Considering the gender attribute analysis we observed from the captured data of the race game (3993 samples, from 15 participants where seven are females and eight are males) that female individuals reported lower incidents of discomfort compared to male participants. This finding disagrees with literature in which Biocca [2] and Kolasinski [6] report that female individuals are more susceptible to symptoms of MS. However, such behavior was only observed in MS scenario and not in CS scenario. Anyways these findings need to be further investigated taking into account more samples and also with other games. Besides that, we were able to observe this effect only in the race game because in the flight game the gender data was not well distributed.

4 CONCLUSION

Conclusively, after applying these incremental and experimental protocols, we produce a 28 attributes dataset (see in Table 1) obtained from the following sources: profile data, questionnaire data, and gameplay data. All the features were captured considering two dependent variables: type of hardware and type of game. These attributes may works as a cybersickness database for machine learning analysis. The complete recorded data description are found in [10] and available in [9] for further analysis and reproducibility.

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