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Cybersickness as a virtual reality side effect: a retrospective study

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RESUMO

Numa nova era acompanhada com a restrição pandémica que vivemos face à COVID-19, a indústria da realidade virtual beneficiou com uma maior procura por parte dos utilizadores em fugir à sua própria realidade para um mundo imersivo, um mundo por explorar, sem sair das suas próprias casas. Não só para usufruto pessoal em entretenimento, a realidade virtual é, hoje em dia, uma nova ferramenta que evolui a cada dia que passa, sobretudo na área Medicina na sua prática e no seu ensino (cirurgias laparoscópicas e outras técnicas cirúrgicas, encurtar curvas de aprendizagem, ensino da anatomia, tratamento de perturbações e doenças psiquiátricas). Uma das limitações mais importantes ao uso da realidade virtual, passa pela doença do movimento, que neste contexto é denominada de “cybersickness”. Esta condição limitante não é mais do que o enjoo de movimento em ambientes imersivos estacionários, especialmente em realidade virtual gerada por computadores e ecrãs montados na cabeça, sem movimento real. Sendo uma limitação importante ao uso da realidade virtual, é importante identificar padrões que aumentem estes efeitos não desejados e de alguma forma trabalhar neles, para que sejam o menos limitante possível. Este estudo retrospetivo foi realizado através de um questionário online, distribuído por várias plataformas utilizando dois grandes questionários certificados nesta área. O principal objetivo é quantificar a prevalência e o grau de sintomas de doença de movimento em utilizadores saudáveis do Oculus Quest 2, um ecrã montado na cabeça, em diferentes posições, desequilíbrio de género na suscetibilidade à doença do movimento e também determinar fatores predisponentes ou potenciais de risco que possam contribuir para ela, utilizando como base o jogo "Epic Roller Coasters". Foi possível encontrar uma relação estatisticamente significativa entre a predisposição, género feminino, a posição de pé, a frequência e o tempo de jogo. Não foi possível relacionar o fator idade com os sintomas de enjoo de movimento reportados. Estes resultados são importantes para que, em estudos no futuro ou na aplicabilidade da realidade virtual, sejam incluídos estes fatores que potenciam os efeitos adversos, em todos os contextos.

Palavras-chave: realidade virtual, enjoo de movimento, cybersickness, oculus quest 2, simulator sickness questionnaire

ABSTRACT

In a new era, accompanied with the pandemic restriction we are living in the face of COVID-19, the virtual reality industry has benefited from a greater demand by users to escape their own reality to an immersive world, a world to explore without leaving their own homes. Not only for personal use in entertainment, virtual reality is nowadays a new tool that evolves every day, especially in medicine in its practice and teaching (laparoscopic surgeries and other surgical techniques, shortening learning curves, teaching anatomy, treating psychiatric disorders and diseases). One of the most important limitations to the use of virtual reality is Motion Sickness, which in this context is called cybersickness. This limiting condition is nothing but MS in stationary immersive environments, especially in virtual reality generated by computers and head-mounted displays, without real movement. Being an important limitation to the use of virtual reality, it is important to identify patterns that increase these unwanted effects and somehow work on them to make them as less limiting as possible. This retrospective study was conducted through an online questionnaire, distributed across several platforms using two large certified questionnaires in this area. Its main objective is to quantify the prevalence and degree of motion sickness symptoms in healthy VR users of Oculus Quest 2, a head mounted display, in different positions (sitting down vs standing up), as gender imbalance in the susceptibility to simulator sickness and as well as determining predisposing or potential risk factors that may contribute to it using the game "Epic Roller Coasters" as basis. It was possible to find a statistically significant relationship between predisposition, female gender, standing position, frequency and time of playing. It was not possible to relate the Age factor with the reported symptoms of Motion Sickness. These results are important so that in future studies or in the applicability of virtual reality, these factors that potentiate adverse effects should be included, in all contexts.

Key words: virtual reality, motion sickness, cybersickness, oculus quest 2, simulator sickness questionnaire

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LIST OF ABBREVIATIONS

CS: Cybersickness

FOV: Field of view

HMDs: Head-mounted displays

IVR: Immersive Virtual Reality (IVR)

MS: Motion sickness

MSSQ: Motion Sickness Susceptibility Questionnaire Short-form

SCT: Sensory Conflict Theory

SS: Simulator sickness

SSQ: Simulator Sickness Questionnaire

VR: Virtual reality

PART I - BACKGROUND

INTRODUCTION

Although being a relatively new technology, the benefit of virtual reality (VR) across companies, institutions or even personal use has been widespread as its potential becomes clearer with every new advancement. Currently, VR technology is becoming increasingly popular. This rising popularity is likely to be aid by the opportunity of economical headsets that deliver high quality immersive experiences and can provide too an opportunity to get away from the reality during the COVID-19 pandemic.

Since VR has sparked some interest, many definitions have been supplied, some of which are contradictory, which unavoidably creates a great deal of confusion for potential users. In its current definition, it is defined as a computer-aided environment with real-time interactive graphics in which users can explore and interact, through three-dimensional models. It allows not only interaction with itself but also with other users. The user has the feeling of immersion in a different world with the possibility to interact and manipulate objects in it. For example, many consider that experiencing VR means being immersed in a virtual world or in 360° videos using an head-mounted displays (HMDs). However, the most important term here is "interaction", between the user and the virtual world. Viewing 360° videos on an HMD is not a VR experience.

In the recent years, many researchers have been trying to find different usage goals and benefits of VR in various areas. When cost or complexity makes it impossible to perform a certain training in a real environment, VR environments can be seen as a solution. The idea behind this, is to lead the human brain to believe irrefutably, that the virtual environment is the real world. For this, VR is designed from real environments in order to meet the user's expectations.

One of the areas that has been widely used is the medical field, where people can practice various scenarios that they will encounter in real life. It is thus possible to achieve greater preparation and skill but when it is really necessary to act, users are ready to perform a certain action in a precise manner. (Martirosov et al., 2021) (Grassini et al., 2021)

Like any other technology, VR has its own disadvantages, one of the most relevant being cybersickness (CS). Since CS represents a considerable obstacle to the use of VR applications, much research has been directed at this subject with the goal of trying to come up with solutions. In the literature, there are some proposed solutions such as systems or questionnaires used to predict, even before it occurs, symptoms of CS. This would be useful since it is often better to anticipate and eliminate a problem before it happens than to face the after-effects that would take longer to correct. (Martirosov et al., 2021)

MOTION SICKNESS AND CYBER-SICKNESS

The concept of motion sickness (MS) was first broached by the Greek physician Hippocrates who wrote: "sailing on the sea proves that motion disturbs the body.", but it was not until 1881 that Irwin characterized it in a disease of repeated oscillatory movements.(Leung & Hon, 2019)

Nowadays, the term VR is commonly referred to modern HMDs. HMDs can offer an immersive user experience, enhancing the sense of induced presence compared to other display media. However, one of the most important limitations of VR is simulator sickness (SS), which raises some questions about its effectiveness and acceptability today.(Grassini et al., 2021)

When reviewing the concept of simulator sickness, not all studies use this terminology to describe the symptoms of MS in VR, but rather the concept of CS, which has been used more widely in the area. (Kennedy et al., 2010) (Grassini et al., 2021).

CS is MS in stationary immersive environments, especially in VR generated by computers and HMDs, without a real movement. In the scientific literature, the term CS is used to refer to the uncomfortable symptoms caused by the use of VR.(Gavgani et al., 2017) (Grassini & Laumann, 2020)

The symptomatology of CS includes dizziness, nausea, vertigo, cold sweats, increased salivation, headaches, sleepiness, , and general discomfort (Duzmanska et al., 2018).

With the increasing demand for and use of VR and computer games in users' daily lives, CS can be expected to be the main obstacle in the adoption and commercial diffusion of the technology, namely in areas of education and training. (Gavgani et al., 2017).

The side effect of CS represents a significant threat to the health and safety of users. As a result, considerable research effort has had the goal of establishing the underlying causes of CS in order to be in a position to decrease its symptoms and enhance the user experience (Grassini et al., 2021).

It is now well established that MS occurs when contradictory signals are being received from the senses of spatial orientation, such as vestibular, visual, and proprioceptive.

To explain CS, two different major theories are described in the literature: ecological theory (postural oscillation) and sensory conflict theory, with sensory conflict theory (SCT) standing out as the most widely accepted.(Zhang et al., 2016) (Gavgani et al., 2017) (Zhang et al., 2016)

According to this theory, MS arises when the movement perceived by vision is discrepant with the signals received by the vestibular sense, based on past experience of the movement. SCT suggests that when any motion detected by vestibular, visual, and proprioceptor systems conflicts with anticipated motion, a centralized signal will gradually build up until an individual variant threshold is achieved. If this threshold is crossed, MS will occur. (Geyer & Biggs, 2018)

In practical terms, this theory proposes that the orientation of the human body in space relies mainly on information obtained through four sensory organs: the semicircular canals that provide information about angular accelerations of the head, the otoliths that notice linear accelerations and inclinations, the visual system that gives information about the positions of the body in space, and the proprioceptive system that allows us to know the position of the limbs. When a conflict occurs among these organs, a condition emerges. In VR and driving simulation, this is typically what happens: when we navigate in a virtual environment, we usually don't move physically. Our eyes sense a movement, but our vestibular system indicates that there is no movement.(Kemeny et al., 2020)

Regardless of the category, three types of conflict can exist: (1) when there are two signals with contradictory information, (2) when signal A exists and signal B is absent, (3) when signal B exists and signal A is absent. The theory predicts that all situations that cause MS can result from the combination of the two categories with the three types of conflict, for a total of six conditions. From Figure 1, we can identify two categories, each with three conflict types. (Walker et al., 2010)

Conflict type	Category A Conflicting sensory information: Visual (VIS) ↔ Vestibular (VES)	Category B Conflicting sensory information: Semicircular canals (SC) ↔ Otolith organs (OT)
Type 1 Conflicting motion-related input from two sensory systems	**A1** VIS ≠ VES – Watching waves over the side of a swaying ship – Making head movements while wearing an optical device that distorts the visual field or inverts it by means of a prism	**B1** SC ≠ OT – Vestibular Coriolis reaction. Head movement about an axis not identical with the body's axis of rotation, e.g., nodding the head while revolving on a rotating chair (Lansberg provocation test)
Type 2 First input signals motion, second input does not	**A2** VIS+ VES– – „Pseudo motion sickness," „simulator sickness" – In a stationary simulator or cinema, watching a film shot from a moving vehicle or aircraft subjected to linear and/or angular accelerations	**B2** SC+ OT– – Caloric nystagmus – Alcohol-related nystagmus. Head movements during weightlessness („space sickness")
Type 3 Second input signals motion, first input does not	**A3** VIS– VES+ – Riding inside a jolting vehicle without any external visual reference – Reading a book below deck on board ship	**B3** SC– OT+ – Rotation at a constant speed about the body's long axis when horizontal („barbecue rotation")

Figure 1: *Six types of kinetogenic sensory conflict, with examples*

It is postulated that this conflict is mediated by the cerebellum, namely the information between the semicircular canals and macules with the flocculonodular lobes of the cerebellum. Since one of the functions of the cerebellum is to predict the future position of the body in space, the function of the flocculonodular lobes is likely, to predict when a state of disequilibrium will occur. This allows the appropriate corrective signals to be sent to the bulbar reticular formation before the person becomes unbalanced. Patients with spinocerebellar resection or degeneration aren't susceptible to MS (Sakata et al., 2004)

Thus, (Thomas A. Stoffregen & Riccio, 1991) developed the ecological theory, which relies on postural oscillation: MS stems from extended periods of postural instability.

Sensory signals such as visual, auditory, vestibular and proprioceptive signals from the entire body set off the body balance function.(Kemeny et al., 2020) When exposed to 3D visual stimuli, this balance mechanism may not function properly, implying that the brain fights to keep the body in a stationary vertical position. Thus, it has been shown that significant increases in postural oscillation precede MS (T. A. Stoffregen et al., 2000) providing valuable insight into how to enhance the tracking of MS and thereby prevent it.

VR IN MEDICINE

HMDs, with their various motion tracking sensors, allow each VR user, a better perception of stereoscopic 3D images and a better spatial position. In addition, there is the possibility to interact, through joysticks and gloves, with various virtual objects as well as a greater sense of immersion through sounds with integrated headphones. As a result, it is possible to confuse the real world with the virtual world, look around and move around.

Because of these particularities, during the last decade the application of VR, has surpassed gaming and entertainment, reaching areas such as clinical medicine.

Several researchers and even doctors explore the beneficial effects of VR simulators, both in physical therapy, surgical and anatomical teaching, as well as approach to psychiatric disorders and management of chronic and acute pain. (Li et al., 2017)

Concerning the scholar medical curriculum, the benefits of Immersive Virtual Reality (IVR) in teaching are still a matter of discussion, but evidence gathered so far suggests that it can improve the acquiring of knowledge in anatomy by incorporating and improving traditional learning methods. Indeed, immersion in the virtual scene allows multiple points of view, even those impossible through cadaveric dissection, and reinforces the comprehension of spatial and relations between organs. The high involvement and commitment in the learning process provided by IVR also seems to increase the retention of acquired concepts. VR can provide users with a realistic environment to practice and get used to specific surgical procedures, shortening the learning curve, preventing any unnecessary risks. This approach can be beneficial for both the training of novice surgeons and the practice of skilled surgeons. (Rizzetto et al., 2020)

For a long time, surgical techniques were acquired and improved under the supervision of more experienced surgeons, and surgical training was based on this. The problem arises when observation is no longer sufficient, due to the advancement and evolution of various surgical techniques. Training is thus constrained, and the new specialists finish their training without being allowed to actively participate in real procedures. (Li et al., 2017)

A controlled and specific virtual environment can solve these problems, so that the new specialists have a more adequate training with the acquisition of basic skills without the need for patient input. The psychomotor performance of a trainee can be directly assessed in an objective manner by the various simulators. Examples are time to complete a given task, number of injuries caused, anatomical patterns identified, patient satisfaction, among others. (Li et al., 2017)

Given the major concerns about the effectiveness of surgical trainees after completion of their specialty and that the level of performance required of surgeons is increasing under medicolegal pressure , IVR could provide a safe and effective response to the growing need for training and professional skills (Rizzetto et al., 2020)

Researchers believe, in several meta-analyses, that is a relationship towards a positive effect observed when supplementing the laparoscopic trainee with VR simulations. (Portelli et al., 2020) Additionally, Portelli highlighted that VR training enhanced aspects crucial for adequate surgical performance.

As stated, participants in the VR training model completed the evaluation in a shorter period of time compared to the control group. In addition, participants shortened operation time, improved instrument and tissue manipulation techniques. If such parameters were translated into practice, the study believe that the VR training model would allow for a decreased economic burden, a decreased operation time and incidence of surgical complications and better patient safety system.(Portelli et al., 2020)

However, it is worth noting some limitations, particularly in accuracy and effectiveness that still needs technological advancements and improvements. Notably, palpable properties, density of structures, and even convex surfaces are difficult to simulate. (Li et al., 2017)

In the context of treating psychological disorders, VR can also be an asset. In treatments, exposure therapy is usually used, where patients face the various situations, they fear. It is important to help them organize their emotions and anxiety and thereby get a different perspective on the nature of the consequences they fear or their beliefs. VR devices also have the advantage that they can be used in private environments such as the doctor's office or even in patients' own homes, being an additional help in managing unwanted feelings in controlled and emotionally safe environments.

It is to be expected that this therapy has many obstacles in its realization, because of the many complex conditions associated with these psychological disorders and their recreation in a real environment, like fear of flying, claustrophobia, acrophobia or generalized social phobia. (Li et al., 2017)

From a 6-month randomized controlled trial on acting out social anxiety, in vitro exposure through VR simulators showed more favorable and significant results than in vivo exposure. (Bouchard et al., 2017)

There is therefore a future prospect of combining VR therapy with other therapeutic methods, since the treatment of psychiatric illnesses is sometimes long. VR can provide diverse and vivid content, and this can be a great help to patients.

PART II - METHODS & MATERIALS

QUESTIONNAIRE

After reviewing the literature, describing and understanding CS registers, a questionnaire was developed to quantify the prevalence and degree of MS symptoms in healthy VR users of Oculus Quest 2 (Figure 3), an HMD, in different positions (sitting down vs standing up), as gender imbalance in the susceptibility to simulator sickness and as well as determining predisposing or potential risk factors that may contribute to it (relationship between susceptibility to MS and simulator sickness; time of continuous exposure to VR and frequency with which subjects play). (Xu et al., 2020) (Grassini & Laumann, 2020)

The game "Epic Roller Coasters" was chosen (In Figure 2, some images from the game "Epic Roller Coaster" are illustrated), a VR experience categorized, by the game's creators and those responsible for the Oculus Quest store, into intense on a scale of comfort: comfortable, moderate to intense. Participants were asked if they had ever experienced MS: "do you sometimes feel like nauseated, abdominal discomfort or even vomiting playing VR games, like Epic Roller Coaster?”

Figure 2: Example of scenes from “Epic Roller Coaster”, B4T Games.

Figure 3: Oculus Quest 2 - HMD

The survey was designed through the Google online forms tool, comprising a first part aimed at the socio-demographic characterization of the sample and a second part comprising a set of questions specifically developed on different aspects related to the theme of this study. (**See Attachments**)

The survey, comprising a first part for the Motion Sickness Susceptibility Questionnaire Short-form (MSSQ), age, gender and a second part comprising a set of questions specifically developed about, "How frequently do you use VR?, On average how much time (without pauses) do you spend playing VR games? Do you usually feel more symptoms in which position (standing up vs sitting down)? as well as the use of the Simulator Sickness Questionnaire (SSQ).

The questions that make up the survey were developed according to multiple response models.

Before the survey itself, a short introductory note was prepared to contextualize the respondent about the framework and purpose of the survey. This was followed by a declaration of informed consent, in which the respondent authorizes the storage, analysis, and processing of his/her answers within the scope of this study, always guaranteeing the anonymity and confidentiality of the data provided.

In the first part of the questionnaire, the following questions were defined and the following answer options were allowed:

- Gender: *male; female*
- Age: *Bellow 35 years; 35 years or above*
- MSSQ

In the second part of que survey, the following questions were defined and the following answer options were allowed:

How frequently do you use VR?	On average, how much time (without pauses) do you spend playing VR games, like Epic Roller Coasters?	Do you usually feel more symptoms in which position?
•Every day •Every week •Every month •Rarely	•Less then 10 minutes •Between 10-20 minutes •More then 20 minutes	•Sitting down •Standing up

The survey was distributed through multiple resources, (Facebook groups with international communities with over 5 000 members and VR forums) trying to maximize the sample size.

During a period of 5 months, starting on April 15th 2021 and ending on August 23rd 2021, the survey was disseminated and responses were received, with a total of 350 responses.

The data were then extracted from the Google online forms platform through an Excel file containing the respondents' answers.

STATISTICS

The Statistical Package for Social Sciences (IBM® SPSS®) software, version 28.0, was used for the statistical treatment and analysis of the data.

The process of statistical treatment and analysis of the data comprised the following steps:

1. Creating a database in SPSS software by importing the data generated, in Excel format, by Google's online forms platform.

2. Definition and configuration of variables for later statistical analysis:
   a. Each multiple-answer question on the form was converted into a qualitative variable (nominal or ordinal), the respective answer options being considered as the allowed values for that variable.

3. Calculation of MSSQ score (Part A (Child) + Part B (Adult)) and SSQ score (from three subscales: Nausea + Oculomotor disturbances + Disorientation, which are combined to produce an overall SS score)
   a. Each answer was converted into 1 point, in order to calculate the final score through the official formula

4. Descriptive statistical analysis of the absolute, relative and relative cumulative frequencies of the sociodemographic variables (present in the 1st part of the form) and of the variables corresponding to the study questions (present in the 2nd part of the form), developed using the tools included in the SPSS and Microsoft Excel software, namely graphs and tables.

5. Study the normality of quantitative samples and perform the appropriate tests to confirm or reject the various hypotheses present in the study

MSSQ

MS, which is characterized by nausea, vomiting, cold sweats, and pallor, can result from being exposed to low-frequency acceleration, and frequently happens in modern forms of transportation and during sea travel. (Lamb & Kwok, 2015)

A standardized measure of MS susceptibility will provide a prediction of which individuals are likely to experience MS during particular movement conditions (Lamb & Kwok, 2015)

(J. T. Reason, 1968) established the older form of the MSSQ, which was further developed by Reason and Brand (J. Reason, 1978). The basic form of the survey evaluated individuals' exposure to and reported the experience of MS in nauseogenic environments (e.g., cars, boats, amusement fair rides) in both children and adults. (Golding, 1998) has simplified the scoring system and condensed the survey from 54 to 18 items, retaining a high correlation with the long-form MSSQ (Golding, 2006)

The MSSQ measures how frequently participants have felt sick in cars, buses or coaches, trains, planes, small boats, ships (e.g., canal ferries), swings on playgrounds, traffic circles on playgrounds, and large dippers or fairground rides in the past.(Golding, 2006).

Through the questionnaire (*Figure 4*), the participants are asked to choose between not applicable/never traveled, never felt sick (score 0), rarely felt sick (score 1), sometimes felt sick (score 2), and often felt sick (score 3).

The MSSQ is separated into a section for childhood experiences (before age 12) and a section for adult experiences (past 10 years). Both a childhood and adult MSSQ score can be calculated following a scoring procedure suggested by Golding (2006).

For Part A (Child): MSA = (total sickness score child) x(9)/(9-number of types not experienced as a child). Where a subject has not experienced any forms of transport a division by zero error occurs. It is not possible to estimate the subject's MS susceptibility in the absence of any relevant motion exposure.

For Part B (Adult) is the same as section A but using just the data from Part B. The final Score of MSSQ is given by the sum between total the Part A (Child) MSA score and the Part B (Adult) MSB. (Golding, 2006)

	Not applicable—Never traveled	Never felt sick	Rarely felt sick	Sometimes felt sick	Frequently felt sick
Cars					
Buses or coaches					
Trains					
Aircraft					
Small boats					
Ships, e.g., channel ferries					
Swings in playgrounds					
Roundabouts in playgrounds					
Roller coasters, Funfair rides					
	t	0	1	2	3
Raw score	$\frac{(totalsicknessscorechild)x(9)}{9-numberoftypesnotexperiencedasachild} + \frac{(totalsicknessscoreadult)x(9)}{9-numberoftypesnotexperiencedasanadult}$ The total sickness score is found by adding the score for each environment ("t" counts as 0) The number of types not experienced is found by counting the number of boxes in the "t" column Note that if the number of types not experienced is equal to 9 (none of the environments experienced), a division by 0 occurs, which implies the impossibility to estimate a participant's motion sickness susceptibility without any relevant motion exposure				

Figure 4: *MSSQ*

SSQ

SSQ is the most commonly used measure of CS. (Kennedy et al., 1993). The SSQ contains 16 items rated by participants as "none," "mild," "moderate," or "severe." These items form three subscales, (1) nausea, (2) oculomotor disturbances (such as headaches, eye fatigue, and blurred vision), and (3) disorientation, which are combined to produce an overall SS score. (Kim et al., 2018)

It might be feasible to use the symptom subscales of the SSQ to differentiate between various kinds of simulated environments based on the symptoms that participants displayed over a wide range of exposures. It might also be able to make forecasts as to the symptoms that a particular simulator might produce, given its characteristics and the clusters of symptoms produced by similar simulators. (Kim et al., 2018). SSQ is also used for providing an ideal virtual environment for HMDs, which recently has gained significant focus.

	Weight		
SSQ symptom	Nausea	Oculomotor	Disorientation
General discomfort	1	1	
Fatigue		1	
Headache		1	
Eyestrain		1	
Difficulty focusing		1	1
Increased salivation	1		
Sweating	1		
Nausea	1		1
Difficulty concentrating	1	1	
Fullness of head			1
Blurred vision		1	1
Dizzy (eyes open)			1
Dizzy (eyes closed)			1
Vertigo			1
Stomach awareness	1		
Burping	1		
Total	[1] × 9.54	[2] × 7.58	[3] × 13.92
Total SSQ score = ([1] + [2] + [3]) × 3.74			

Figure 5: *SSQ*

PART III - RESULTS

STATISTICAL DATA

SEX

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	249	71,1	71,1	71,1
	Female	101	28,9	28,9	100,0
	Total	350	100,0	100,0	

AGE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<35	158	45,1	45,1	45,1
	35+	192	54,9	54,9	100,0
	Total	350	100,0	100,0	

Figure 6: *Descriptive Analysis of the Statistical Data on Age and Gender*

Figure 6 shows that of the total 350 respondents, 101 (28,9%) are female and 249 (71,1%) are male. Therefore, the sample is mostly male.

Regarding age, 158 (45,1%) respondents are in the age group below 35 years old, 192 (54,9%) are in the age group from 35 years old and above. It is therefore observed that the absolute majority of the respondents are 35 years old and above.

FREQUENCY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Every day	139	39,7	39,7	39,7
	Every Week	165	47,1	47,1	86,9
	Every month	37	10,6	10,6	97,4
	Rarely	9	2,6	2,6	100,0
	Total	350	100,0	100,0	

Figure 7: *Descriptive Analysis of the Statistical Data on Playing Frequency*

Regarding how often respondents play VR, 139 (39,7%) plays every day, 165 (47,1%) every week, 37 (10,6%) every month and 9 play rarely.

TIME

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<10 min	19	5,4	5,4	5,4
	10-20 min	68	19,4	19,4	24,9
	>20 min	263	75,1	75,1	100,0
	Total	350	100,0	100,0	

POSITION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sitting Down	86	24,6	24,6	24,6
	Standing up	201	57,4	57,4	82,0
	None	63	18,0	18,0	100,0
	Total	350	100,0	100,0	

Figure 8: *Descriptive Analysis of the Statistical Data on Playing Time (without pauses) and Position*

Respondents were also asked, on average how much time (without pauses) do they spend playing VR games, like epic roller coaster. 19 (5,4%) less than 10 minutes, 68 (19,4%) between 10 to 20 minutes and 263 (75,1%), absolute majority of the respondents, more than 20 minutes.

Finally, it was asked in which position (Sitting Vs Standing) the respondents felt more MS symptoms (presented in the previously answered simulator sickness questionnaire). The vast majority, 201 (57,4%) reported more symptoms when standing, while only 86 (24,6%) reported sitting. 63 (18%) reported no differences between the two different positions.

MSSQ SCORE AND SSQ SCORE

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MSSQ	350	0	47	12,17	11,350
SSQ	350	0	2197	514,67	417,015
Valid N (listwise)	350				

Figure 9: *Descriptive analysis of the results of both questionnaires.*

For a total of 350 responses, the MSSQ score had a minimum value of 0 and a maximum of 47, with some variability (x̄ = 12,17; s= 11,350). The SSQ score had a minimum value of 0 and a maximum value of 2197, with a significant variability (x̄=514,67; s= 417,015).

Frequency distribution of SSQ score and MSSQ score is illustrated in the histograms below.

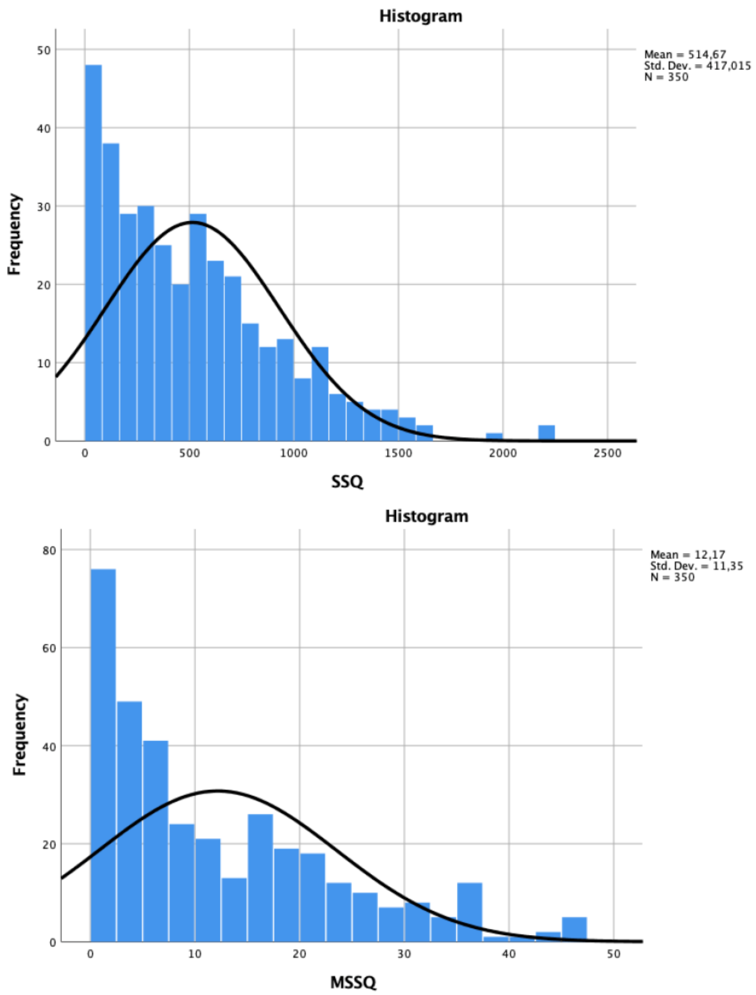

Figure 10: *Histogram from results of both questionnaires.*

			SSQ	MSSQ
Spearman's rho	SSQ	Correlation Coefficient	1,000	,384**
		Sig. (2-tailed)	.	,000
		N	350	350
	MSSQ	Correlation Coefficient	,384**	1,000
		Sig. (2-tailed)	,000	.
		N	350	350

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 10: *Spearman Correlation from MSSQ and SSQ scores.*

There was a positive association between participant MSSQ and SSQ scores (r=0,384, p=0,000).

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
MSSQ	,142	350	,000	,887	350	,000
NAUSEA	,145	350	,000	,917	350	,000
OCULOMOTOR	,155	350	,000	,896	350	,000
DISORIENTATION	,146	350	,000	,889	350	,000
SSQ	,109	350	,000	,922	350	,000

a. Lilliefors Significance Correction

Figure 11: *Tests of Normality of quantative samples (MSSQ and SSQ Score)*

A Shapiro–Wilk test of normality indicated that MSSQ score was not normally distributed (p = 0.000). A Shapiro-wilk test of normality indicated that the Nausea (p = 0.000), Oculomotor (p = 0.000), Disorientation (p = 0.000) and SSQ total score (p = 0.000) was not normally distributed.

I tested all hypotheses at significance level α = 0.05. Since the sample was not normally distributed, I used the non-parametric Kruskal-Wallis and Mann-Whitney tests.

GENDER vs MSSQ & SSQ SCORE

	SEX	N	Mean Rank	Sum of Ranks
MSSQ	Male	249	161,82	40292,00
	Female	101	209,24	21133,00
	Total	350		
SSQ	Male	249	161,51	40216,50
	Female	101	209,99	21208,50
	Total	350		

Test Statistics[a]

	MSSQ	SSQ
Mann-Whitney U	9167,000	9091,500
Wilcoxon W	40292,000	40216,500
Z	-3,978	-4,062
Asymp. Sig. (2-tailed)	,000	,000

a. Grouping Variable: SEX

Figure 12: *Test Statistics using Mann-Whitney Test and respective Ranks to compare the influence of gender on both questionnaires*

		SEX	Percentiles 5	10	25	50	75	90	95
Weighted Average (Definition 1)	MSSQ	Male	,00	,00	2,71	7,00	17,00	25,50	31,44
		Female	,00	2,00	4,75	14,00	24,50	36,64	43,44
	SSQ	Male	,00	35,68	154,09	383,95	655,10	1007,41	1151,85
		Female	35,68	65,49	291,57	648,89	976,36	1380,58	1577,58
Tukey's Hinges	MSSQ	Male			3,00	7,00	17,00		
		Female			5,00	14,00	24,00		
	SSQ	Male			156,41	383,95	653,75		
		Female			291,57	648,89	976,36		

Figure 13: *Percentiles*

The media of MSSQ score from females (median: 14; Q1: 4,75 – Q3: 24,50) was significantly higher, compared to males (median: 7; Q1: 2,71 – Q3: 17) (U =9167; p = 0,000).

The media of SSQ score from females (median: 648,89; Q1: 291,57 – Q3: 976,36) was significantly higher, compared to males (median: 383,95; Q1: 154,09 – Q3: 655,10) (U =9091,5; p = 0,000)

AGE VS SSQ SCORE

	AGE	N	Mean Rank	Sum of Ranks
SSQ	<35	158	173,17	27360,50
	35+	192	177,42	34064,50
	Total	350		

Test Statistics[a]

	SSQ
Mann–Whitney U	14799,500
Wilcoxon W	27360,500
Z	–,391
Asymp. Sig. (2–tailed)	,696

a. Grouping Variable: AGE

Figure 15: *Test Statistics using Mann-Whitney Test and respective Ranks to compare the influence of Age on SSQ score.*

			Percentiles						
		AGE	5	10	25	50	75	90	95
Weighted Average (Definition 1)	SSQ	<35	,00	64,03	172,54	435,15	709,25	1097,69	1249,99
		35+	,00	35,68	173,46	427,82	777,06	1126,79	1365,12
Tukey's Hinges	SSQ	<35			175,48	435,15	705,59		
		35+			174,13	427,82	771,56		

Figure 16: *Percentiles*

SSQ total severity scores did not differ between the age groups, U = 14799,5, p = 0,696.

POSITION VS SSQ SCORE

	POSITION	N	Mean Rank
SSQ	Sitting Down	86	184,73
	Standing up	201	187,83
	None	63	123,56
	Total	350	

Test Statistics[a,b]

	SSQ
Kruskal-Wallis H	20,312
df	2
Asymp. Sig.	,000

Figure 17: *Test Statistics using Kruskal-Wallis Test and respective Ranks to compare the influence of Position (Standing up Vs Sitting Down) on SSQ score.*

			Percentiles						
		POSITION	5	10	25	50	75	90	95
Weighted Average (Definition 1)	SSQ	Sitting Down	9,92	64,03	209,33	511,89	806,70	1096,48	1229,57
		Standing up	53,99	100,59	246,84	464,36	758,25	1137,83	1451,97
		None	,00	,00	35,68	163,74	607,08	1038,75	1245,85
Tukey's Hinges	SSQ	Sitting Down			211,16	511,89	805,30		
		Standing up			246,84	464,36	755,93		
		None			35,68	163,74	593,76		

Figure 18: *Percentiles*

The media of SSQ score from Standing Position (median: 464,36; Q1: 246,84 – Q3: 758,25) was slighly higher, compared to Sitting Position (median: 511,89; Q1: 209,33 – Q3: 806,7) (H =20,312; p = 0,000)

FREQUENCY VS SSQ SCORE

	FREQUENCY	N	Mean Rank
SSQ	Every day	139	153,06
	Every Week	165	184,44
	Every month	37	195,61
	Rarely	9	275,56
	Total	350	

Test Statistics[a,b]

	SSQ
Kruskal-Wallis H	18,391
df	3
Asymp. Sig.	,000

Figure 19: *Test Statistics using Kruskal-Wallis Test and respective Ranks to compare the influence of Frequency of Playing on SSQ score.*

			Percentiles						
		FREQUENCY	5	10	25	50	75	90	95
Weighted Average (Definition 1)	SSQ	Every day	,00	35,68	116,09	287,16	653,75	1065,83	1350,07
		Every Week	,00	35,68	197,10	526,67	798,45	1093,40	1294,78
		Every month	75,20	186,24	331,78	464,36	715,72	1100,19	1275,76
		Rarely	291,57	291,57	685,17	897,45	1299,35	.	.
Tukey's Hinges	SSQ	Every day			119,75	287,16	642,27		
		Every Week			199,42	526,67	791,61		
		Every month			336,30	464,36	703,87		
		Rarely			720,25	897,45	1262,32		

Figure 20: *Percentiles*

Regarding frequency, the SSQ score was significantly higher the less often the respondents played VR (H=18,391; p= 0,000) specifically, by order: rarely (median: 897,45; Q1: 685,17 – Q3: 1299,35), every month (median: 464,36; Q1: 331,78 – Q3: 715,72), every week (median: 526,67; Q1: 197,10 – Q3: 798,45) and every day (median: 287,16; Q1: 116,09 – Q3: 653,75)

TIME OF EXPOSURE VS SSQ SCORE

	TIME	N	Mean Rank
SSQ	<10 min	19	240,79
	10-20 min	68	202,96
	>20 min	263	163,68
	Total	350	

Test Statistics[a,b]

	SSQ
Kruskal-Wallis H	16,514
df	2
Asymp. Sig.	,000

Figure 21: *Test Statistics using Kruskal-Wallis Test and respective Ranks to compare the influence of Frequency of Playing on SSQ score.*

			Percentiles						
		TIME	5	10	25	50	75	90	95
Weighted Average (Definition 1)	SSQ	<10 min	,00	163,74	376,62	703,87	1092,23	1393,08	.
		10-20 min	44,41	98,98	308,68	550,75	847,60	1181,17	1401,30
		>20 min	,00	35,68	144,44	367,57	699,45	1056,25	1252,41
Tukey's Hinges	SSQ	<10 min			476,21	703,87	1075,36		
		10-20 min			309,41	550,75	835,37		
		>20 min			148,10	367,57	698,00		

Figure 22: *Percentiles*

Regarding playing time, without breaks, the SSQ score was significantly higher the shorter the exposure time (H=16,514; p= 0,000) specifically, by order: less than 10 minutes (median: 703,87; Q1: 376,62 – Q3: 1092,23), between 10 to 20 minutes (median: 550,75; Q1: 308,68 – Q3: 847,60) and more than 20 minutes (median: 367,57; Q1: 144,44 – Q3: 699,45).

PART IV - DISCUSSION

This study aimed to investigate the effects, namely CS, when playing one of the most popular VR games, Epic Roller Coaster on aspects of gender difference, position, age, frequency and exposure time.

When analyzing the questionnaire responses, the results build on existing evidence of a correlation between predisposition to MS and the severity of symptoms experienced during the VR experience, in line with the hypothesis that MSSQ will provide a prediction of which individuals are likely to experience MS during particular movement conditions.

GENDER DIFFERENCE

Both in reports and in controlled investigations, MS tends to be more common among females than among males. The classic example is perhaps seasickness, where women are more likely than men by a ratio of approximately 5:3 (Lawther & Griffin, 1986). Investigators have started to assess the possibility that gender differences may be extended to visually induced MS. A number of studies have assessed the possibility of proving empirically the generalizability of women's susceptibility to MS to visually induced SS in lab controlled experiments; nevertheless, the results have been varied (Munafo et al., 2017)

The reasons for the sexual imbalance in SS symptoms remain unclear. Nevertheless, some scientists have attempted to explain these discrepancies with hormone levels during the female menstrual cycle (Grassini & Laumann, 2020). (Clemes & Howarth, 2005) demonstrated that women are more susceptible to SS, particularly on day 12 of their cycle. The authors have suggested that this effect may be related to estradiol. A large amount of research has demonstrated that fluctuating levels of female reproductive hormones are able to have a generalized influence in many different physiological and sensory systems. Changes over the cycle in susceptibility to nauseogenic stimuli have been described in the literature on postoperative nausea and vomiting and decompression sickness. (Clemes & Howarth, 2005)

However, many researchers have been critical of this belief. They alternatively suggested that susceptibility to SS might have to do with the fact that females usually have a wider field of view (FOV), and a larger FOV is likely to be correlated with an increased susceptibility to SS.

Women have marginally wider peripheral FOV, slightly larger vertical FOV, and more active dorsal visual flow and thus better peripheral vision than men(Grassini & Laumann, 2020) .This other study explain this difference using sensory conflict theory, reasoning that males may be better able to adjust to sensory conflict than women, which might lead to higher CS in women than in men (K. Stanney et al., 2020)

Another interpretation is that the difference may be a result of different responses, or attitudes, among men and women, in that women may be more likely to confess that they do not feel well, whereas men may be less likely to relate symptoms.(Clemes & Howarth, 2005).

Some researchers also note that this gender difference may result from a discrepancy in the manner in which self-reports of symptoms, generally done via questionnaires, are completed, because men may misreport their susceptibility to the disease. Even though it is generally accepted that women are more likely to over-report symptoms than men.(Kemeny et al., 2020)

In addition, females may have a smaller interpupillary distance and some HMDs may not be capable of being set appropriately, thereby creating eye strain and general discomfort. (Saredakis et al., 2020)

The relevance of this thread suggests that more investigation is required to further understand the incidence of CS based on sex differences.

Regarding the gender difference, this analysis indicates that women, in addition to having a greater predisposition to MS (U =9167; p = 0,000), reported greater symptom severity (U =9091,5; p = 0,000). Although there are some discrepant results in the literature, the analysis supports the theory that MS tends to be more common among women than men.

STANDING VS SITTING POSITION

Previous research has demonstrated that postural instability precedes movement sickness (T. A. Stoffregen et al., 2000) so these characteristics could be used for prediction of CS.

The incidence of sickness was the highest during the standing condition and was significantly lower when the subjects were seated. The difference in incidence as a result of posture could have implications for theories of the etiology of MS. (Merhi et al., 2007).

According to the postural instability theory, the fact that the body tends to be more stable sitting than standing can explain some results. (Merhi et al., 2007) In addition, a significant reduction in the incidence of MS can be observed in sitting positions (for example, when playing video games) when compared to standing positions (Merhi et al., 2007)

Although postural sway represents an important indicator of CS, previous studies have also shown that for seated situations, such as driving situations, the correlation between MS and postural sway may not be evident and may be negative. (Kemeny et al., 2020) This does not imply, however, that it is not worthwhile to measure postural sway in sitting situations, since the literature also provides evidence that body motion differs between users who develop symptoms of MS and non-ill users in such situations (Kemeny et al., 2020)

Regarding the answers about the **position** in which respondents felt more symptoms, there was a correlation between severity and the standing position ($H = 20,312$; $p = 0,000$), a result that corroborates one of the theories of MS, the theory of postural instability.

EXPOSURE TIME AND FREQUENCY

Since the initial use of VR, extended use of HMDs has been described to induce CS effects, stomach discomfort, nausea, and vomiting, especially during rotations. Timing of exposure is a crucial factor, as it is directly proportional to the severity and duration of its effects: the longer the exposure, the stronger and longer the effects will be. Curiously, however, repeated experience of the same exposure, with a delay of several days between experiments, can give simulator disease resistance, and it is advisable to take breaks in some cases. (Kemeny et al., 2020)

A recent review found that some people can develop a resistance or adjust over time to VR sickness, especially over multiple sessions. Content and duration are significant contributing factors that may increase the likelihood of illness symptoms. (Saredakis et al., 2020)

A roller coaster ride may be more susceptible to induce cyber sickness to the level of severity at which users will request to discontinue the experience. For example, almost 67% of respondents in a study using a virtual roller coaster environment were incapable of finishing a 14 min exposure time. (Saredakis et al., 2020).

As for playing time, without breaks, the SSQ score was significantly higher the shorter the exposure time (H=16.514; p= 0.000). The results do not fit the theory that exposure time is directly proportional to the severity of cybersquatting effects. The justification may be explained by the fact that respondents answered exposure time, without breaks, while playing Epic Roller Coaster, a game characterized as uncomfortable on the MS scale. Now, according to (Saredakis et al., 2020), the content may be a contributing factor to the intensification of symptoms, such as a roller coaster simulator. Respondents with higher SSQ scores may not hold the experience for longer, as it is too uncomfortable to continue playing without a break.

Being used to visual stimuli found in immersive technologies has a beneficial effect on decreasing the incidence of CS (K. M. Stanney & Kennedy, 1997). Therefore, people who have a significant gaming experience may be less susceptible to the disease than nongamers (Rosa et al., 2016) which means that people's own experience may have a powerful bearing on their susceptibility to CS. Concerning **frequency**, the SSQ score analysis was significantly higher the less frequently the respondents played VR, (H=18,391; p= 0,000) a result that goes in favor of the hypothesis that the greater the experience and frequency with which one plays, the less susceptibility to CS symptoms.

AGE

Several studies have been investigating if the age of users can impact the level of CS. Nevertheless, the trials have shown varied mixed results.

In accordance with (Häkkinen et al., 2002), age had some meaning regarding eye strain symptoms with the older participants reporting more serious symptoms. This may be linked to age-related alterations in the oculomotor system, making the elder participants more prone to eye strain. HMDs were given to subjects aged between 18 and 41 years and experienced a virtual race environment. The result demonstrated that an elder age group exhibited a statistically significant increase in SSQ scores in comparison to a younger age group. (Häkkinen et al., 2002)

However, a meta-analysis (Saredakis et al., 2020) has shown the exact opposite outcome. In other words, subjects whose average age was below 35 years self-reported a greater total SSQ score when compared to the oldest age group. This cutoff was used to correspond to theories of both sensory conflict and postural instability. For instance, vestibular function involved in the sensory conflict theory starts to decrease around age 40 With relevance to postural instability theory, changes in impaired postural stability have been documented to begin in the 30-39. (Saredakis et al., 2020)

It has been noted, in fact, that younger generations are less likely to CS than older generations because younger people are higher consumers of displays and games from their early infancy than elders.

Further reports have found that older people might experience greater dizziness and nausea with 2D stimulation, while for younger people, symptoms of more blurry and double vision, dizziness, and nausea may be observed with 3D movies, suggesting that elderly adults are less responsive to higher vergence demand, which is the latent source of blurry and double vision (Yang et al., 2012).

In addition, because of the loss of accommodation capacity, older adults may also experience increased CS symptoms when watching 2D content because they have to conserve the identical level of vergence response. However, younger viewers typically have a robust accommodation capacity for vergence processes, which is more prone to inducing side effects when viewing 3D content (Yang et al., 2012).

In fact, SSQ total severity scores did not differ between **age groups** ($U = 14799.5$, $p = 0.696$) and no correlation could be demonstrated between age groups and the severity of CS symptoms. In reality, this is not so straightforward, and previous studies have shown conflicting results. Future research could attempt to replicate the current study using a different, more subdivided age group in order to highlight greater variances between them.

LIMITATIONS

The methodological choices were conditioned by the choice of a game, Epic Roller Coaster, an uncomfortable game on the sickness scale, which makes it unknown to what extent these analysis results are feasible for other types of games. It should be noted that the role of content plays a large role in the progression and severity of symptoms.

Another limitation of the current study is the use of a self-reported scale, influenced by individual subjectivity and may under or over-report symptoms. Although SSQ has been approved and widely used in different studies and areas due to its certified and significant correlations with various physiological aspects, it would be important, for example, to analyze the more objective physiological variations of the VR experience.

In the questionnaire, based on the bibliographic references previously studied and reviewed, I decided to put as a closed question the age of the participants, which conditioned only two age groups. It was not possible to reach a statistically significant conclusion between the age factor and the severity of the reported symptoms, so I think it limited this objective of the study.

Future research could attempt to replicate the current study using a different, more subdivided age group in order to highlight greater variances between them, using open response when questioning the age of the users.

FUTURE PROSPECTS

From my perspective, a separate study could focus on a cost-benefit analysis in incorporating VR into both surgical training and chronic disease management as well as medical education. An analysis that compares traditional methods with this innovative world that could bring so much benefit.

It is also important to consider the impact and satisfaction that the use of a new innovative tool has on patients' lives. With the results of this retrospective study, it will be easier to identify a priori factors that can lead to CS and work on prevention when using VR as well as to include the long-term impact of this adverse effect of technology on the user.

PART V - CONCLUSION

Being a highly complex set of symptoms, CS requires a deep study on many aspects, from the visual system to individual proprioception. Nowadays, it is a highly relevant investigation to find the underlying reasons for this condition and reasons that may aggravate the symptoms.

The commonalities between the evolution of medicine and new technologies are expanding with each passing day. Different benefits have been exemplified in the field of Psychiatry, Surgery, and medical education.

The prevalence of CS in VR users is considerable and one of the main barriers to its use. It can not only create discomfort but also make users reluctant to experience the world of VR, and they are conditioned to test the full potential that VR has to offer.

This retrospective study, has made notice of several factors that contribute to CS, which will continue to be a present problem even though there is continued technological evolution. It was possible to see a relationship between female gender and predisposition as well as a greater severity of MS symptoms, the importance of body position when exposed to VR, exposure time, and personal experience affecting susceptibility to MS.

The identification of these characteristics can improve our understanding and perception of CS and be an asset for application to everyday people by trainers, researchers or health professionals.

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"When you have a dream that you can't let go of, trust your instincts and pursue it. But remember: Real dreams take work, They take patience, and sometimes they require you to dig down very deep. Be sure you're willing to do that." – Harvey Mackay

PART VII - REFERENCES

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PART VIII - ATTACHMENTS

Cybersickness as a Virtual Reality side effect: a retrospective study

Hello, my name is Fábio Duque. I'm a medical student at the Faculty of Medicine of the University of Lisbon and I'm elaborating my master's thesis which theme is "Cybersickness as a virtual reality side effect: a retrospective study"
Although it being a relatively new technology, the benefit of virtual reality across companies, institutions or even personal use has been widespread as its potential becomes clearer with every new advancement.
Despite the recent increase in VR popularity, many users still experience VR SICKNESS when using head-mounted displays.
Therefore, these questionnaires aims to quantify the prevalence and degree of motion sickness symptoms in healthy VR users as well as the different positions (sitting down vs standing up) as well as determining predisposing or potential risk factors that may contribute to it.

The present Informed Consent informs all research participants, in a clear and unequivocal way, about the process of data collection and processing regarding the study "Cibersickness as a Virtual Reality Side Effect: a retrospective study". Therefore, this retrospective study aims to quantify the prevalence and degree of motion sickness symptoms in healthy VR users, in different positions (sitting down vs standing up), different genders and as well as determine predisposing or potential risk factors that may contribute to it. The involvement in this study is completely voluntary and it's based on the gathering of information from the adult population (18 years and older) through a survey that will take about 10 minutes. By agreeing to participate in this study, you are asked to answer truthfully all the questions that will be presented to you. All information collected will be confidential and will only be used for research purposes.Any information obtained as part of this study that you can identify will be confidential and will not be disclosed without your prior permission. All data collected will be stored in a way that allows conformity with the Portuguese and European Union legislation concerning data protection and privacy.All personal data will be stored separately from the data resulting. This will be ensured by appropriate technical and organizational measures.Measures will be taken to protect personal data against accidental or unlawful destruction or accidental loss, alteration, unauthorized disclosure or access. As part of a risk mitigation policy, data backup and recovery procedures will be implemented to protect data.At the end of the project, all participants' personal data will be deleted. The study does not involve any potential risks, whether social, legal, or financial.You are informed that you may withdraw at any time and that if you have any questions throughout the research you may contact the responsible team at the e-mail address: fabioduque@campus.ul.pt *

◉ I declare that I am over 18 years old, I HAVE READ and ACCEPT to voluntarily participate in the investigation

○ I declare that I have read and DO NOT ACCEPT to participate voluntarily in the investigation.

Motion Sickness Susceptibility Questionnaire

This questionnaire is designed to find out how susceptible to motion sickness you are, and what sorts of motion are most effective in causing that sickness. By sickness we mean feeling queasy or nauseated or actually vomiting.

Please State Your Sex *

- ◯ Male
- ◯ Female

Age *

- ◯ Bellow 35
- ◯ 35 years or above

As a CHILD (before the age 12), how often did you Feel Sick or Nauseated *

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Felt Sick Sometimes	Frequently Felt Sick
Cars	◯	◯	◯	◯	◯
Buses or Coaches	◯	◯	◯	◯	◯
Trains	◯	◯	◯	◯	◯
Aircrafts	◯	◯	◯	◯	◯
Small Boats	◯	◯	◯	◯	◯
Ships, e.g. Channel Ferries	◯	◯	◯	◯	◯
Swings in playgrounds	◯	◯	◯	◯	◯
Roundabouts in playgrounds	◯	◯	◯	◯	◯
Big Dippers, Funfair Rides	◯	◯	◯	◯	◯

Over the LAST 10 YEARS, how often did you Feel Sick or Nauseated *

	Not Applicable - Never Travelled	Never Felt Sick	Rarely Felt Sick	Felt Sick Sometimes	Frequently Felt Sick
Cars	◯	◯	◯	◯	◯
Buses or Coaches	◯	◯	◯	◯	◯
Trains	◯	◯	◯	◯	◯
Aircrafts	◯	◯	◯	◯	◯
Small Boats	◯	◯	◯	◯	◯
Ships, e.g. Channel Ferries	◯	◯	◯	◯	◯
Swings in playgrounds	◯	◯	◯	◯	◯
Roundabouts in playgrounds	◯	◯	◯	◯	◯
Big Dippers, Funfair Rides	◯	◯	◯	◯	◯

SIMULATOR SICKNESS QUESTIONNAIRE

In this part, we'll ask you to rate the severity of 16 symptoms that you may have experienced after playing VR.
It will be IMPORTANT to have a VR experience:

- on EPIC ROLLER COASTER;

- SITTING DOWN vs STANDING UP on the same app;

How frequently do you use VR? *

- ◯ Every day
- ◯ Every week
- ◯ Every month
- ◯ Rarely

On average how much time (without pauses) do you spend playing VR games? *

- ◯ Less then 10 minutes
- ◯ 10-20 minutes
- ◯ More then 20 minutes

How do you usually feel after playing that app? *

	Not at all	Slightly	Moderately	Very
General discomfort	◯	◯	◯	◯
Fatigue	◯	◯	◯	◯
Headache	◯	◯	◯	◯
Eyestrain	◯	◯	◯	◯
Difficulty focusing	◯	◯	◯	◯
Increased salivation	◯	◯	◯	◯
Sweating	◯	◯	◯	◯
Nausea	◯	◯	◯	◯
Difficulty concentrating	◯	◯	◯	◯
Heavy head	◯	◯	◯	◯
Blurred Vision	◯	◯	◯	◯
Dizzy (eyes open)	◯	◯	◯	◯
Dizzy (eyes closed)	◯	◯	◯	◯
Vertigo	◯	◯	◯	◯
Abdominal Discomfort	◯	◯	◯	◯
Burping	◯	◯	◯	◯

Do you usually feel more symptoms in which position?

- ◯ Sitting down
- ◯ Standing up
- ◯ None