FINAL PROJECT PRESENTATION - BRED

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AGENDA

- Motivation
- Hypothesis
- Previous Work
- Our Design
- Data Analysis
- Results
- Limitations
- Future Work

Why are we interested in the world of VR and Immersion?

MOTIVATION

- Uses of VR
- Presence and its role in VR development
- How do we Maximize Presence?

VIRTUAL REALITY IS THE FUTURE

VR Presents a unique opportunity for individuals to experience a 'different world', without having to face the risks/inconveniences associated with it.

Useful for:

- Training in the military
- Exposure therapy in Psychology
- Gaming
- Broadcasting media etc.

And many more fields...

WHAT IS PRESENCE AND WHY DOES IT MATTER?

- Presence is a **sense of 'being there'** - to what extent does the simulated environment become your subjective reality?
- Historically, Media has evolved to increase this sense of presence:
- Text -> Pictures -> Movies -> XR -> Neuralink?
- Higher sense of Presence enhances Ecological validity of studies which use VR.
- Leads to better connect with and replication of real-world scenarios.
- Helps us imagine and experience fantastical things, too! (Harry Potter, Wizard of Oz, etc)

MAXIMIZING SENSE OF PRESENCE

- **Immersion** is a measure of how well a device is able to mimic real-world experience.
- Factors like FOV, Fidelity, refresh rate etc.
- Increasing level of Immersion can be a way to increase sense of presence of an individual.
- Even so, Immersion != Sense of Presence!
- In this Project, we have decided to focus on one aspect of Immersion in VR; namely: **Fidelity**.

LITERATURE REVIEW

Aspects Considered:

- **Spatial Learning:** Process by which one acquires a mental representation of one's environment.
- **Interaction Fidelity:** degree to which sensory-motor feedbacks resemble real-world interactions.
- **Display Fidelity:** degree to which display features resemble real-world features.

DEFINING OUR SCOPE:

- Due to the large variety of applications of VR, we have limited ourselves to looking at tasks that involve **Spatial Learning**.
- Among different aspects of Immersion, we have decided to look at how **Fidelity** impacts **performance in a spatial learning task.**

1) MURCIA-LÓPEZ, M., AND STEED, A. (2016). THE EFFECT OF ENVIRONMENTAL FEATURES, SELF-AVATAR, AND IMMERSION ON OBJECT LOCATION MEMORY IN VIRTUAL ENVIRONMENTS.

FIGURE 1 | Participant placing the three objects in the recall stage. Plastic stools were used as objects for the study. Three retroreflective markers were attached to each stool for optical tracking.

- **Task:** Memorizing locations of objects in a room and recreating the placements from memory.
- Found that a combination of **enhanced Interaction Fidelity and Display Fidelity** (among other things) **improves performance** in a spatial learning task.
- However, the paper does not talk about each of these aspects separately.

2) SRIVASTAVA P. ET. AL. (2019). DESKTOP VR IS BETTER THAN NON-AMBULATORY HMD VR FOR SPATIAL LEARNING.

Figure: FPP of VR environment being explored

- **Task:** Recreating a map of the environment from memory after exploration.
- Found that when Interaction fidelity is kept constant, **higher Visual Fidelity has a slightly detrimental effect on performance** in a spatial learning task.
- Keeps Interaction Fidelity fixed and varies Display Fidelity only.
- Shows that the discussion is more nuanced than simply saying Higher Fidelity = better performance.

SOME OTHER LITERATURE:

- Slater M. et. Al. (2022): A Separate Reality: An Update on Place Illusion and Plausibility in Virtual Reality. - Definitions of Presence, Immersion and Fidelity have been taken from here.
- Sharples S. (2008): Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems – Talks about simulator sickness in VR HMD devices.
- Witmer B., Singer M. (1998): Measuring Presence in Virtual Environments: A Presence Questionnaire – Presence questionnaire adopted from here.
- Kennedy et al. (1993): Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Simulator Sickness – Simulator Sickness Questionnaire adopted from here.

KEY TAKEAWAYS:

- There has been some previous attempts to figure out how Fidelity affects performance in spatial learning tasks.
- Although Fidelity seems to positively influence performance, just increasing Visual Fidelity has little to no effect.
- **The question remains: What about Interaction Fidelity? More specifically, method of locomotion?**

- **H_A:** There is an effect of the method of locomotion on spatial learning tasks in VR HMD environments.
- **H_0:** There is no effect of the method of locomotion on spatial learning tasks in VR HMD environments.

HYPOTHESIS

MAIN QUESTION: HOW DOES METHOD OF LOCOMOTION AFFECT PERFORMANCE IN A SPATIAL LEARNING TASK IN A VR HMD ENVIRONMENT?

VARIABLES AND OPERATIONALIZATION

INDEPENDENT VARIABLE

- **Method of locomotion:** An important aspect of interaction fidelity in VR.
- The 2 levels of the I.V. that we are looking at are Joystick vs Walking.

DEPENDENT VARIABLES

1) **Spatial memory of the objects in the VE – number of objects correctly placed (ordinal, from 0 to 4)**

2) **Total time taken to place objects (continuous, measured during recall phase)**

-> Sense of presence (continuous, score obtained from presence questionnaire)

-> Simulator Sickness (continuous, score obtained from SSQ)

CONTROL VARIABLES

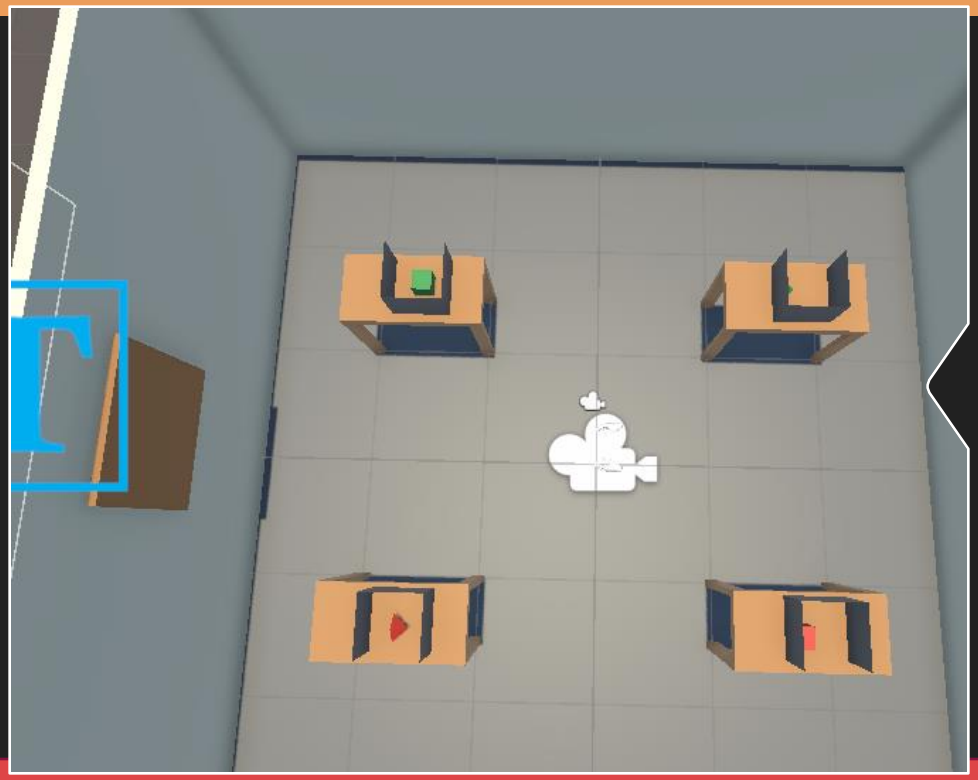
- **Display fidelity**
- **Difficulty/complexity of the task**
- **External environmental conditions**

POSSIBLE CONFOUNDS

- **Performance effect – Controlled for by creating a between-group design.**
- **Visual Impairments – We created the task taking this into consideration. We also recorded participants' visual impairments as part of demographic.**
- **Familiarity with VR – We recorded the participants' VR familiarity.**

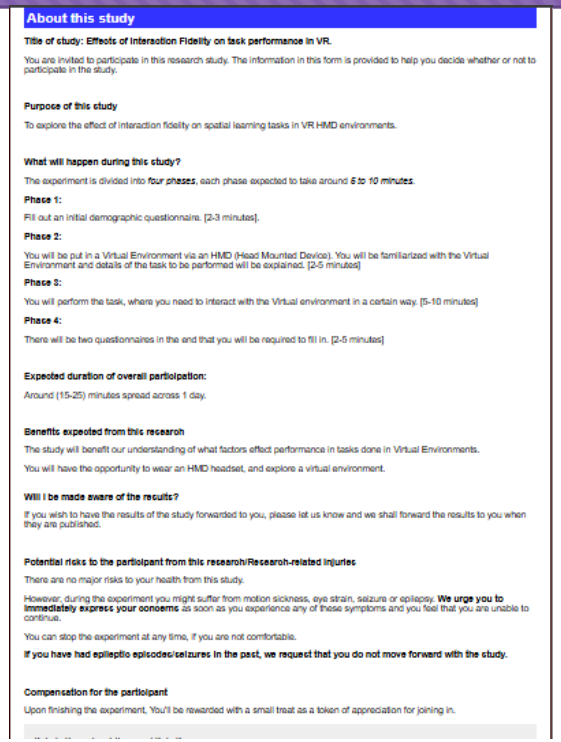
True Experiment

EXPERIMENT DESIGN



Top View of Virtual Room, with 4 objects

- **Task:** Memorizing spatial locations of objects in a room and recreating the placements from memory.
- Flow of Experiment:
- a) Participant consent and demographic questionnaire
- b) Familiarization with the VR environment and explanation of task.
- c) Memory phase of the task (60s)
- d) Recall phase of the task (timed)
- e) Post-hoc Questionnaires



About this study

Title of study: Effects of interaction Fidelity on task performance in VR.

You are invited to participate in this research study. The information in this form is provided to help you decide whether or not to participate in the study.

Purpose of this study

To explore the effect of interaction fidelity on spatial learning tasks in VR HMD environments.

What will happen during this study?

The experiment is divided into *four phases*, each phase expected to take around *5 to 10 minutes*.

Phase 1:

Fill out an initial demographic questionnaire. [2-3 minutes].

Phase 2:

You will be put in a Virtual Environment via an HMD (Head Mounted Device). You will be familiarized with the Virtual Environment and details of the task to be performed will be explained. [2-5 minutes]

Phase 3:

You will perform the task, where you need to interact with the Virtual environment in a certain way. [5-10 minutes]

Phase 4:

There will be two questionnaires in the end that you will be required to fill in. [2-5 minutes]

Expected duration of overall participation:

Around (15-25) minutes spread across 1 day.

Benefits expected from this research

The study will benefit our understanding of what factors effect performance in tasks done in Virtual Environments.

You will have the opportunity to wear an HMD headset, and explore a virtual environment.

Will I be made aware of the results?

If you wish to have the results of the study forwarded to you, please let us know and we shall forward the results to you when they are published.

Potential risks to the participant from this research/Research-related injuries

There are no major risks to your health from this study.

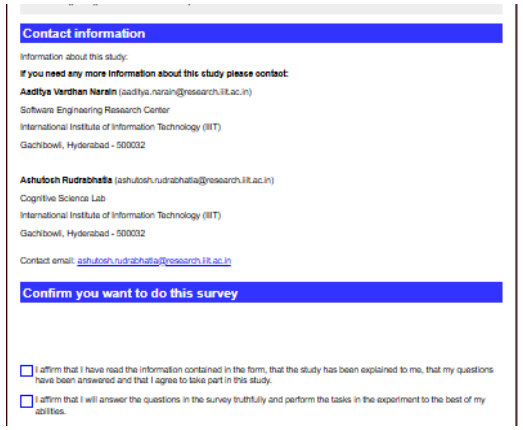
However, during the experiment you might suffer from motion sickness, eye strain, seizure or epilepsy. **We urge you to immediately express your concerns** as soon as you experience any of these symptoms and you feel that you are unable to continue.

You can stop the experiment at any time, if you are not comfortable.

If you have had epileptic episodes/seizures in the past, we request that you do not move forward with the study.

Compensation for the participant

Upon finishing the experiment, You'll be rewarded with a small treat as a token of appreciation for joining in.



Contact information

Information about this study:

If you need any more information about this study please contact:

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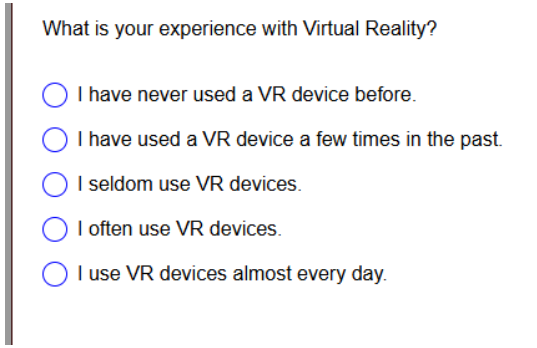
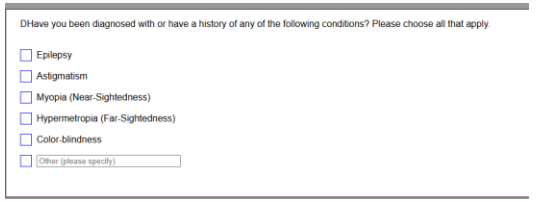
Confirm you want to do this survey

- [ ] I affirm that I have read the information contained in the form, that the study has been explained to me, that my questions have been answered and that I agree to take part in this study.
- [ ] I affirm that I will answer the questions in the survey truthfully and perform the tasks in the experiment to the best of my abilities.



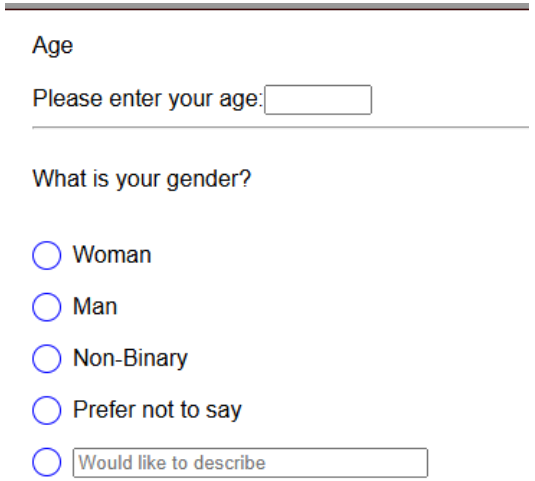
What is your experience with Virtual Reality?

- ◯ I have never used a VR device before.
- ◯ I have used a VR device a few times in the past.
- ◯ I seldom use VR devices.
- ◯ I often use VR devices.
- ◯ I use VR devices almost every day.



DHave you been diagnosed with or have a history of any of the following conditions? Please choose all that apply.

- ☐ Epilepsy
- ☐ Astigmatism
- ☐ Myopia (Near-Sightedness)
- ☐ Hypermetropia (Far-Sightedness)
- ☐ Color-blindness
- ☐ Other (please specify)



Age

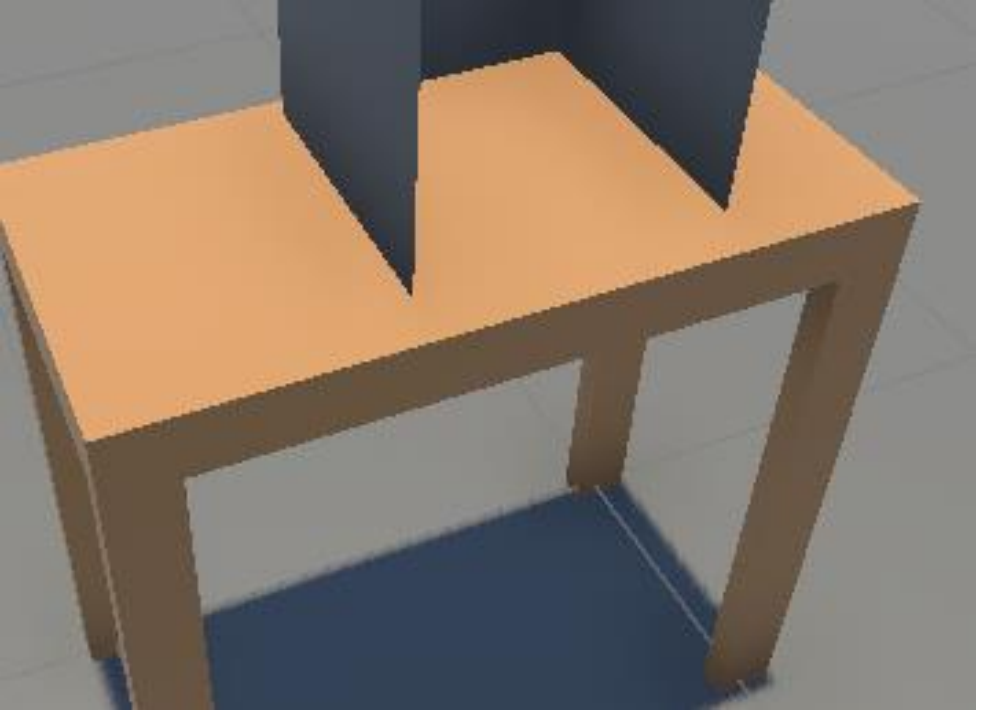
Please enter your age:

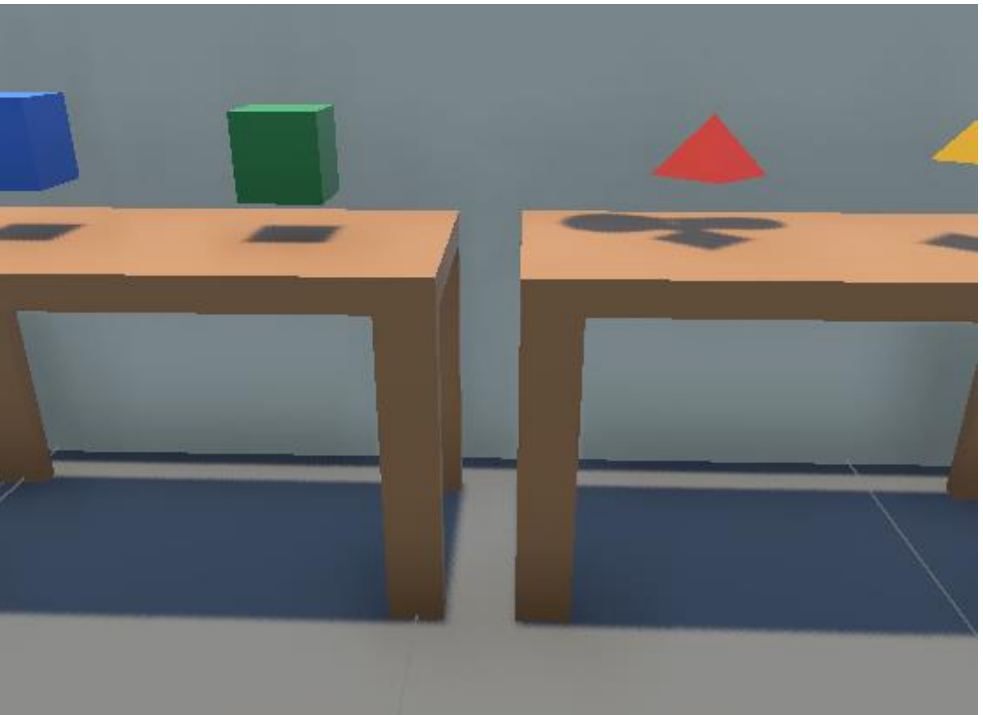
What is your gender?

- ◯ Woman
- ◯ Man
- ◯ Non-Binary
- ◯ Prefer not to say
- ◯ Would like to describe

Consent Form and Demographic Questions

The Dance Room used for experiment



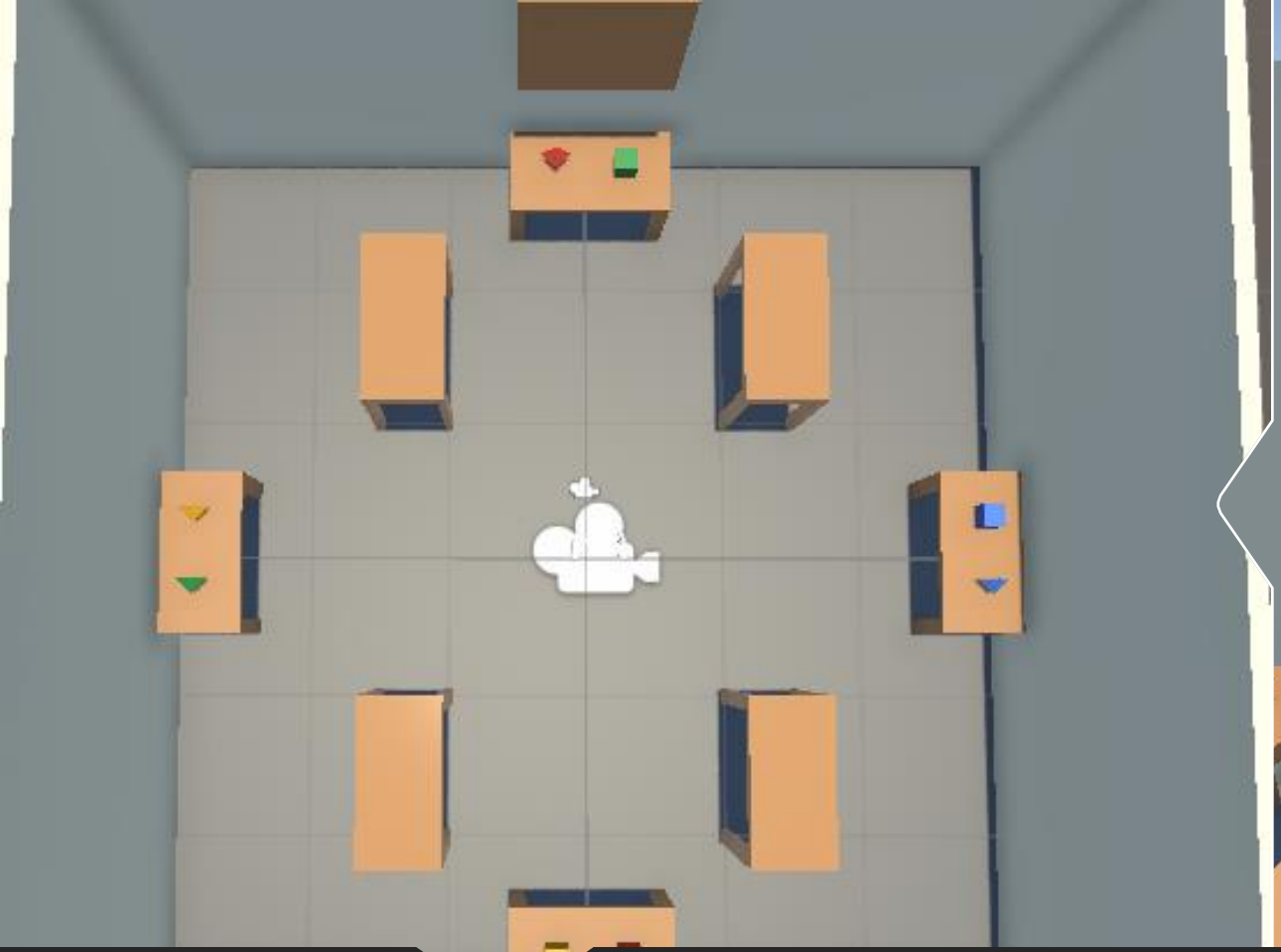


Tutorial

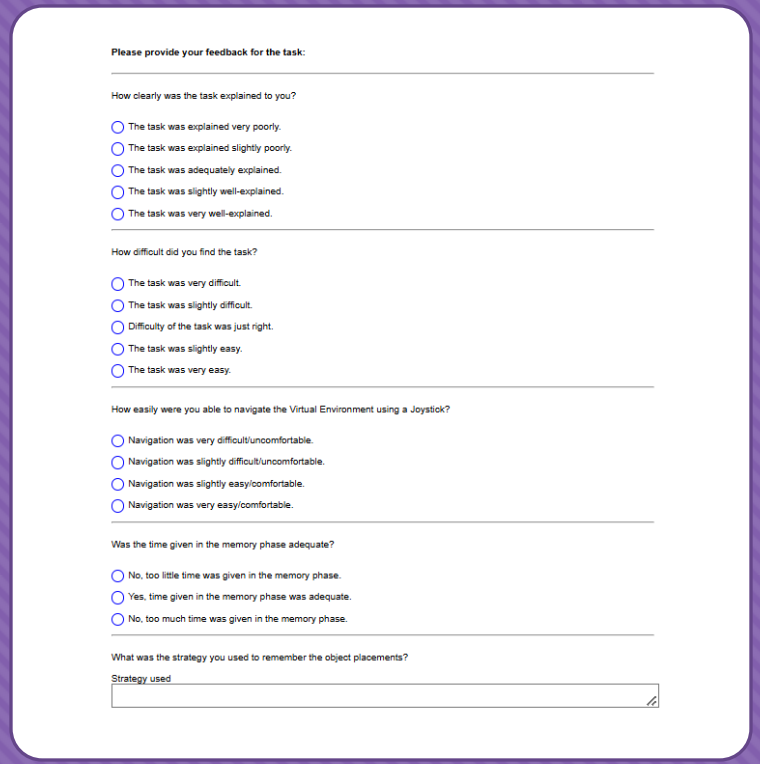
If you are asked to use your joystick, use it to move around, otherwise walk

Familiarization with VR environment and explanation of task

Memory Phase



Recall Phase



Please provide your feedback for the task:

How clearly was the task explained to you?

- The task was explained very poorly.
- The task was explained slightly poorly.
- The task was adequately explained.
- The task was slightly well-explained.
- The task was very well-explained.

How difficult did you find the task?

- The task was very difficult.
- The task was slightly difficult.
- Difficulty of the task was just right.
- The task was slightly easy.
- The task was very easy.

How easily were you able to navigate the Virtual Environment using a Joystick?

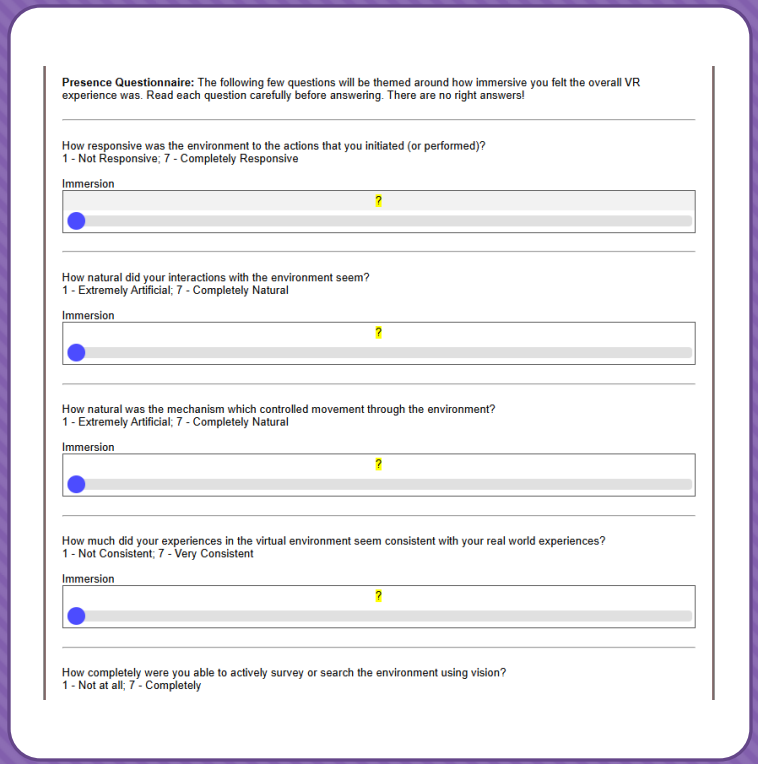
- Navigation was very difficult/uncomfortable.
- Navigation was slightly difficult/uncomfortable.
- Navigation was slightly easy/comfortable.
- Navigation was very easy/comfortable.

Was the time given in the memory phase adequate?

- No, too little time was given in the memory phase.
- Yes, time given in the memory phase was adequate.
- No, too much time was given in the memory phase.

What was the strategy you used to remember the object placements?

Strategy used



Presence Questionnaire: The following few questions will be themed around how immersive you felt the overall VR experience was. Read each question carefully before answering. There are no right answers!

How responsive was the environment to the actions that you initiated (or performed)?
1 - Not Responsive; 7 - Completely Responsive

Immersion

?

How natural did your interactions with the environment seem?
1 - Extremely Artificial; 7 - Completely Natural

Immersion

?

How natural was the mechanism which controlled movement through the environment?
1 - Extremely Artificial; 7 - Completely Natural

Immersion

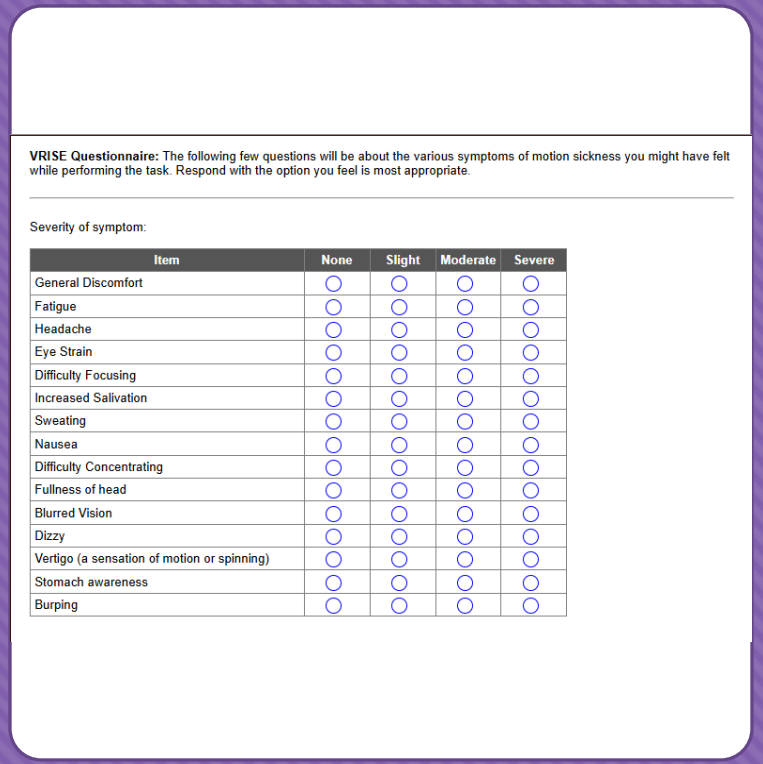
?

How much did your experiences in the virtual environment seem consistent with your real world experiences?
1 - Not Consistent; 7 - Very Consistent

Immersion

?

How completely were you able to actively survey or search the environment using vision?
1 - Not at all; 7 - Completely



VRISE Questionnaire: The following few questions will be about the various symptoms of motion sickness you might have felt while performing the task. Respond with the option you feel is most appropriate.

Severity of symptom:

Item	None	Slight	Moderate	Severe
General Discomfort	○	○	○	○
Fatigue	○	○	○	○
Headache	○	○	○	○
Eye Strain	○	○	○	○
Difficulty Focusing	○	○	○	○
Increased Salivation	○	○	○	○
Sweating	○	○	○	○
Nausea	○	○	○	○
Difficulty Concentrating	○	○	○	○
Fullness of head	○	○	○	○
Blurred Vision	○	○	○	○
Dizzy	○	○	○	○
Vertigo (a sensation of motion or spinning)	○	○	○	○
Stomach awareness	○	○	○	○
Burping	○	○	○	○

Post-Hoc Questions

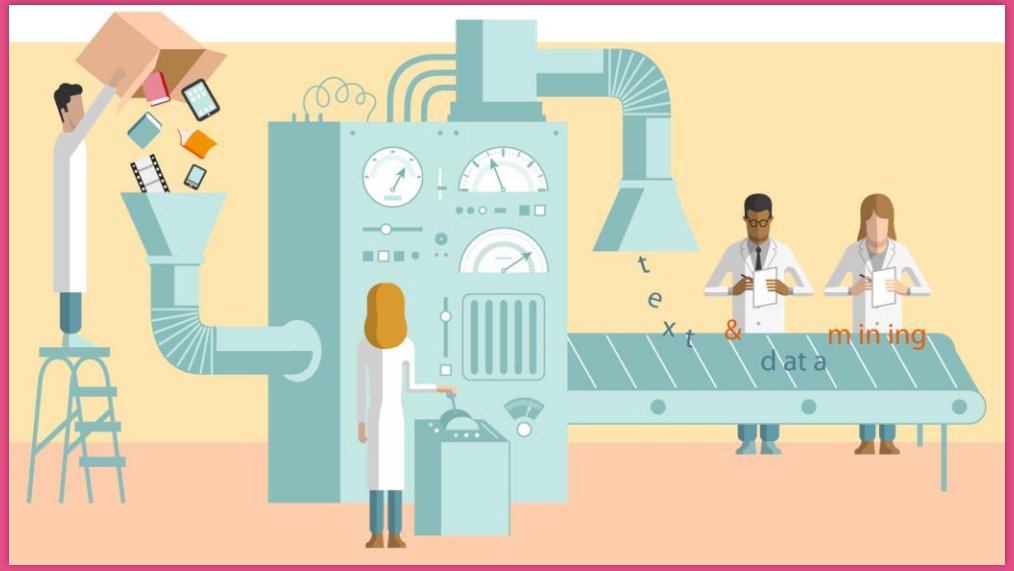
TIMELINE(WE WERE RIGHT ON TIME)

- **Literature Review: (till ~Sept 30)**
- Conduct a review of studies focusing on interaction fidelity, display fidelity, and spatial learning in VR environments. (1-2 weeks)
- **Designing the Experiment: (till ~Oct 18)**
- Finalization of experiment design and building the virtual environment for the decided conditions. (1-2 weeks).
- Preparing the questionnaires and standardizing the format of the experiment (1 week).

- **Data Collection (With Timeline): (till ~Nov 10)**
- Recruit participants, collect demographic data, and administer the VR task. (2-3 weeks)
- **Data Analysis and Report: (till ~Nov 20)**
- Analysis of the obtained variable data and consolidation of results. (1-2 weeks)

DATA COLLECTION

- **Method of sampling:** Convenience Sampling + Snowball Sampling
- **Type of Data:** Quantitative data (both ordinal and continuous)

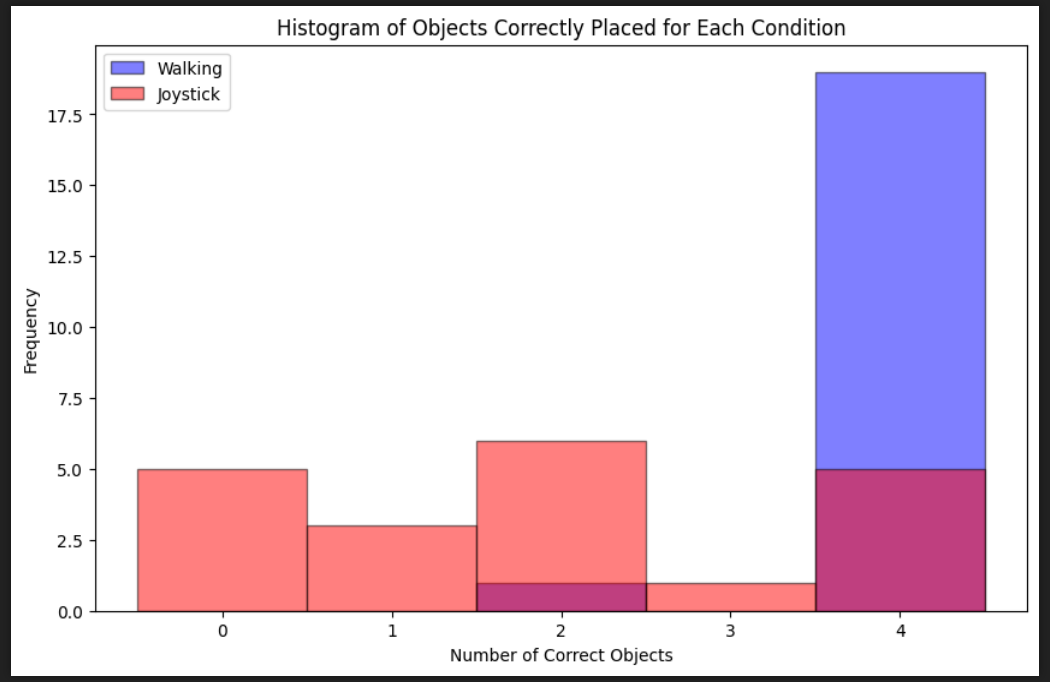


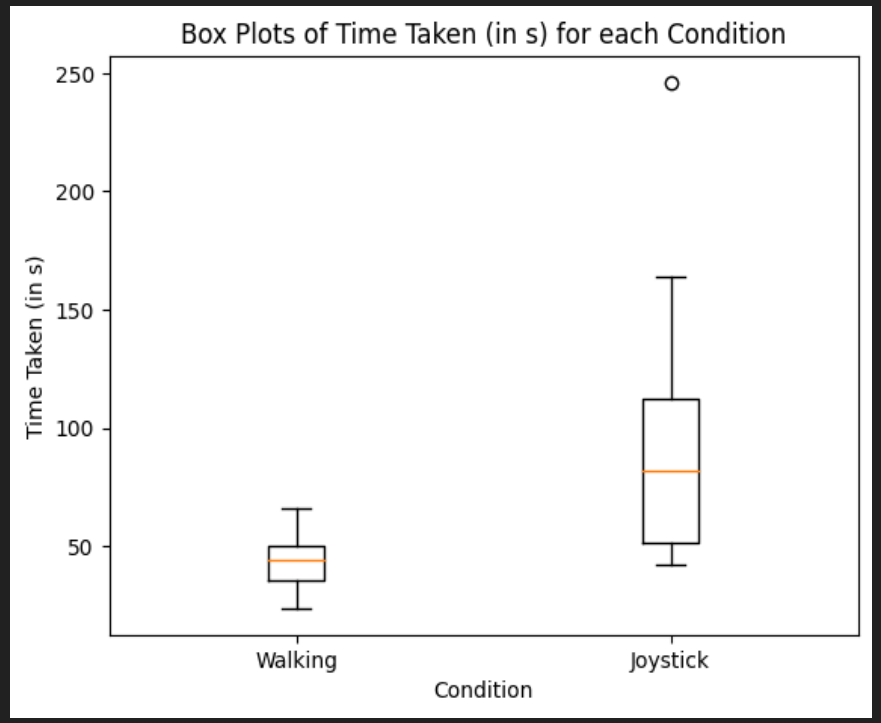
DATA ANALYSIS

DEMOGRAPHIC

- **Total Participants:** 40 (20 for each condition)
- **Gender: Women -** 10, **Men -** 30
- **Age: Mean –** 19.425, **SD -** 0.931
- All participants were IIITH students.

- Most people had little to no prior experience with VR
- A few people reported Myopia (has no effect on experiment), none with colorblindness.
- Average time taken to complete the experiment: 13.050 min, SD: 2.375 min

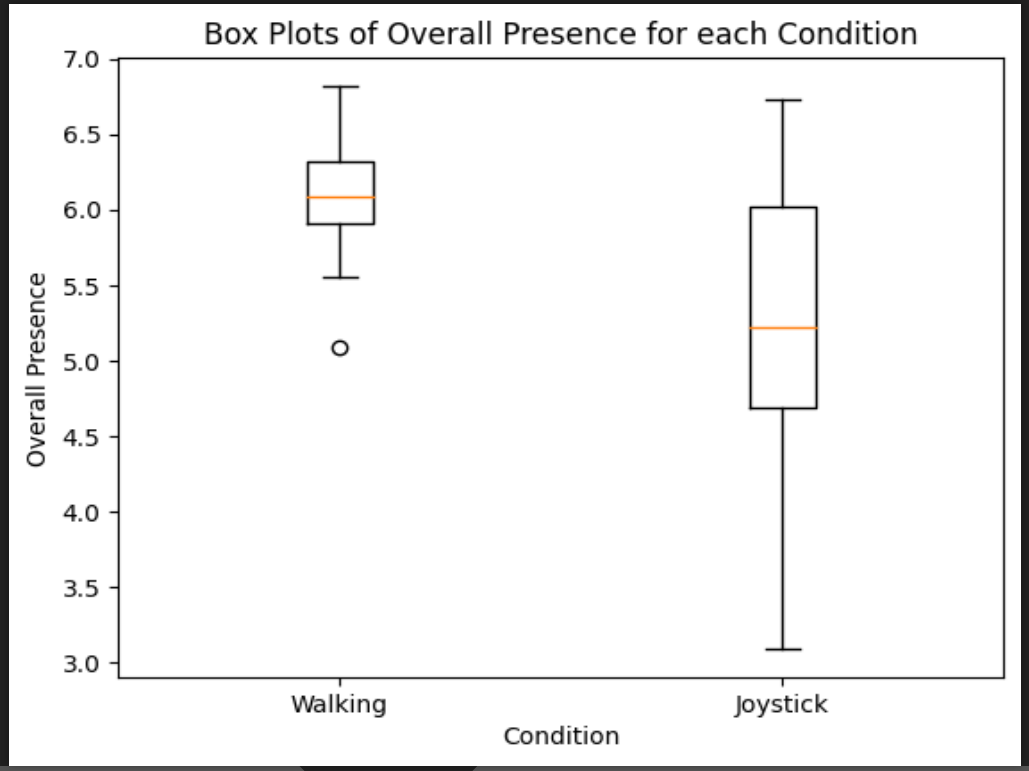


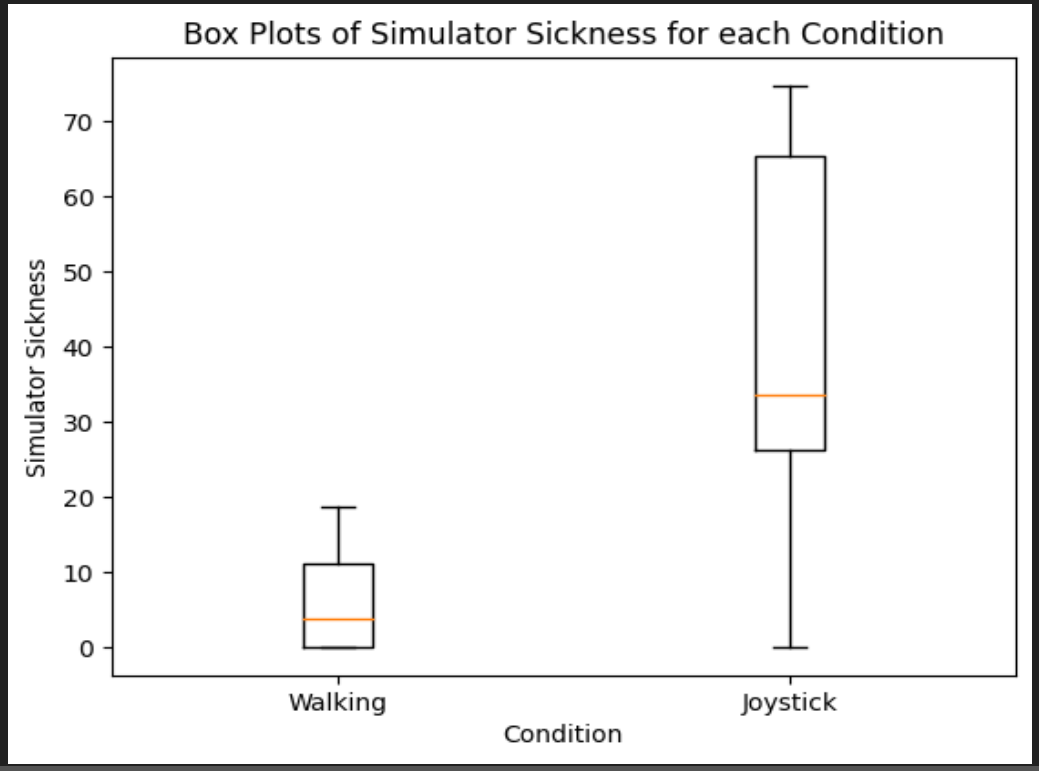


TASK PERFORMANCE

- Time Taken:
- Walking – Mean: 44.07s, Median: 44.40s
- Joystick – Mean: 92.90s, Median: 82.15s
- 1 Outlier – 246s for joystick condition.

- Objects Correctly Placed (out of 4):
- Walking – Median: 4, Mode: 4
- Joystick – Median: 2, Mode: 2
- 1 Outlier – 2 objects, for walking condition.





PRESENCE AND SIMULATOR SICKNESS

- Presence (out of 7):
- Walking – Mean: 6.10, Median: 6.09
- Joystick – Mean: 5.15, Median: 5.22
- 1 Outlier – 5.09, for walking condition.

- SS (out of a max of ~300):
- Walking – Mean: 5.98, Median: 3.74, Mode: 0.
- Joystick – Mean: 40.14, Median: 33.66, Mode: 33.66

TASK FEEDBACK

- **Ease of Navigation:** 4-point lickert scale, from *very difficult/uncomfortable* to *very easy/comfortable*.
- For **Walking** condition, almost everyone found navigation ***very easy/comfortable***.
- For **Joystick** condition, average consensus was that movement was ***slightly easy/comfortable***.
- However, the option ***slightly difficult/uncomfortable*** was selected the most times (**mode**).

Clarity of Instructions: 5-point lickert scale, from *very poorly explained* to *very well-explained*. For both conditions, **Almost everyone** felt that the instructions were **well-explained**.

Difficulty of Task: 5-point lickert scale, from *very easy* to *very difficult*. For **Walking** condition, Almost everyone found the task ***very easy***. For **Joystick** condition, the average consensus was that the task was ***adequately difficulty***.

VALIDITY AND RELIABILITY

- **Standardized questionnaires** – Increased validity.
- **Pilot study** during the experiment design phase – iterative improvement of experiment design

- **Cronbach's alpha to judge the internal consistency** of the various items within each questionnaire.
- **CBA for Presence:** Joystick – 0.903, Walking – 0.446
- **CBA for SSQ:** Joystick – 0.881, Walking – 0.802.

RESULTS AND DISCUSSION

RESULTS

1) Task Performance:

- **Time Taken:** after removing outliers, (IQR method), we got acceptable normality of distribution for each condition (Shapiro-wilk). **Final p-value: $p < 0.001$** (ind. T-test)
- **Objects Correctly Placed:** we chose Mann-Whitney U since normality was not present. **Final p-value: $p < 0.001$**

Null Hypothesis can be Rejected.

RESULTS

2) Simulator Sickness:

- Normality was not observed, so we chose Mann-Whitney U. **Final p-value: p < 0.001.**

3) Presence:

- Normality was observed, so we chose independent T-test. **Final p-value: p < 0.001.**

LIMITATIONS

- A few participants in the Joystick condition complained that the controls were unintuitive – default != good.
- We were unable to conduct multiple trials (performance effect could not be explored)

- **Convenience Sampling:** less external validity.
- Ceiling effect for task performance in walking condition.
- Simulator Sickness is also known to reduce spatial task performance. We were not able to explore this separately.

FUTURE WORK

- More levels can be explored (different types of joysticks, different methods of locomotion in VR like teleportation, etc)
- Replication of this study is encouraged, with different populations of people.

Different tasks (other than spatial memory) can be explored.

Longitudinal study to see whether after proficiency, does the effect vanish.

CITATIONS:

1) Military using VR for Troop Training (link)
2) VR in gaming (link)
3) Srivastava P. et. Al. (2019): Desktop VR Is Better Than Non-ambulatory HMD VR for Spatial Learning. (link)
4) Murcia-Lopez M, Steed A. (2016): The Effect of Environmental Features, Self-Avatar, and Immersion on Object Location in Virtual Environments. (link)
5) Slater M. et. Al. (2022): A Separate Reality: An Update on Place Illusion and Plausibility in Virtual Reality. (link)
6) Zhao J. et. Al. (2020): Desktop versus immersive virtual environments: effects on spatial learning. (link)

CITATIONS (CONTD.):

7) Witmer B., Singer M. (1998): Measuring Presence in Virtual Environments: A Presence Questionnaire. (link)

8) Sharples S. (2008): Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems. (link)

9) Kourtesis P. et. Al. (2019): Virtual Reality Neuroscience Questionnaire (link)

THANK YOU!

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