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Title: VR Nature Therapy: Embodiment and Emotional Regulation Through Immersive Virtual Environments

Authors and Affiliations:

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Author Questionnaire

1. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**

2. Software: Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done**

Videographer: Please record the computer screen for the shots labeled as SCREEN as back-up

3. Filming location: Will the filming need to take place in multiple locations? **No**

4. Testimonials (optional): Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

Current Protocol Length

Number of Steps: 09

Number of Shots: 20 (6 SC)

Introduction

Videographer: Obtain headshots for all authors available at the filming location.

Authors: Please note that **the questions will not appear on screen.** Please answer in **stand-alone full sentence with sufficient context.**

Answers will be slightly edited in accordance with the journal guidelines

INTRODUCTION:

~~**REQUIRED:** Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Junpei Zhong:** Our research explores how immersive virtual reality nature environments can improve mood and body embodiment across different postures and sceneries.
 - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~**Describe the research gap or limitation in existing methods and how this protocol addresses them.**~~

- 1.2. **Junpei Zhong:** Previous studies lacked interactive elements. Our protocol introduces standing and moving in room-scale VR to assess physical engagement effects.
 - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

CONCLUSION:

~~**What does this protocol allow researchers to study or measure?**~~

1.3., Joyce Lau: This protocol allows researchers to measure changes in emotional states and body embodiment before and after virtual nature exposure.

- 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~**Describe the most important consideration or challenge when performing this protocol.**~~

- 1.4. **Joyce Lau:** Ensuring participants move safely within the tracked space without experiencing simulator sickness is crucial for obtaining valid psychological measurements.

- 1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

- 1.5. **Junpei Zhong**: Future studies could explore longer exposure times, clinical populations, or incorporate biofeedback sensors to measure physiological responses alongside self-reports
- 1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research has been approved by the Hong Kong Polytechnic University Institutional Review Board

Protocol

2. Virtual Reality (VR) System Setup

Demonstrators: Junpei Zhong and Joyce Lau

2.1. To begin, connect the virtual reality headset to a high-performance laptop to render 360-degree virtual environments [1-TXT]. Introduce the 5-by-5-meter interaction space to the healthy participant [3].

2.1.1. WIDE: Talent connecting the virtual reality headset to a high-performance laptop in the room-scale setup. **TXT: Game engine version: 2021.3.9f1**

2.1.2. Talent showing the interaction space to the participant.

2.2. Prepare 4-minute-long 360-degree videos consisting of either a forest landscape or a marine environment. Process the recordings using video editing software to stitch multiple angles of landscape scenes [1]. Integrate ambient audio recordings from the natural environments, including bird calls, wind, and wave sounds, and present the audio through stereo headphones integrated with the headset [2].

2.2.1. SCREEN: 2.2.2.

Videographer: Please record the computer screen for the shots labeled as SCREEN as back-up

2.2.2. SCREEN: 2.2.3 00:00-00:04 and 01:21-01:24.

2.3. Map each 360-degree video onto a spherical surface fixed to the scene coordinate system within the game engine to allow viewing through head rotation [1]. Allow participants to move naturally within the tracked space for the standing condition [2], but maintain a fixed video perspective without parallax shift during locational movement [3].

2.3.1. SCREEN: 2.3.1 00:07-00:09 and 00:30-00:37

2.3.2. Participant standing and moving naturally within the tracked 5 meter by 5 meter space while wearing the headset to demonstrate.

2.3.3. SCREEN: 2.3.3 00:18-00:30.

3. Participant Preparation and Experimental Procedure

- 3.1. Recruit a healthy adult participant and obtain baseline responses to a standardized questionnaire [1]. Ensure that the participant provides [2] their responses for the entire questionnaire before beginning the procedure [3].
 - 3.1.1. Talent handing a questionnaire packet to a seated participant.
 - 3.1.2. Close-up of a participant completing the Profile of Mood States questionnaire.
 - 3.1.3. TEXT ON PLAIN BACKGROUND:
 - **Mood States:** Measure anger, confusion, depression, fatigue, tension, and vigor
 - **Experience of Embodiment Scale (EES):** Positive body connection and comfort, body unencumbered adjustment, agency and functionality, experience and expression of sexual desire, attuned self-care, and resisting objectification
 - **Presence Questionnaire (PQ):** Presence in virtual environments
 - **Connectedness to Nature Scale (CNS):** In forest and marine environments
 - **Simulator Sickness Questionnaire (SSQ):** Nausea, oculomotor disturbance, and disorientation symptoms
- 3.2. Conduct four virtual reality sessions in a fixed sequence consisting of seated forest viewing [1], seated marine viewing, standing forest viewing, and standing marine viewing [2]. Administer each virtual reality session for 4 minutes during which participants experience immersive 360-degree natural scenery [3].
 - 3.2.1. Talent instructing the participant to take seat on the designated chair.
 - 3.2.2. LAB MEDIA: 3.2.1B Video editor: Sequentially highlight the 4 boxes from top to bottom
 - 3.2.3. SCREEN: 3.3.2 00:21-00:30
- 3.3. Seat participants in a comfortable chair for the seated forest and seated marine conditions and maintain the seated position throughout each 4-minute session [1]. During the standing sessions, allow natural movement within the tracked space [2].
 - 3.3.1. Participant seated in a comfortable chair wearing the virtual reality headset.
 - 3.3.2. Participant walking naturally within the tracked play area while wearing the headset.
- 3.4. Immediately after each condition, administer the same standardized questionnaires

used at baseline to assess post-exposure changes in mood, embodiment, presence, connectedness to nature, and simulator sickness [1-TXT].

- 3.4.1. Participant removing the virtual reality headset and completing questionnaire forms at a desk. **TXT: Conduct data analysis using statistical software**

Results

4. Results

- 4.1. Significant improvements were observed from pre- to post-exposure across multiple mood dimensions. The Friedman Test revealed significant reductions in negative mood aspects [1].
 - 4.1.1. LAB MEDIA: Table 1. *Video editor: Highlight the rows “anger” “confusion” “depression” “fatigue” “tension” and show the significant mark in the pre- versus post-exposure comparison.*
- 4.2. Vigor showed no significant change between pre- and post-exposure [1].
 - 4.2.1. LAB MEDIA: Table 1. *Video editor: Highlight the row “vigor” .*
- 4.3. Body Unencumbered Adjustment increased significantly from pre- to post-exposure [1].
 - 4.3.1. LAB MEDIA: Table 1. *Video editor: Highlight the row “BUA”*
- 4.4. Other embodiment measures, including Positive Body Connection and Comfort, Agency and Functionality, Experience and Expression of Sexual Desire, Attuned Self-Care, and Resisting Objectification, showed no significant differences between pre- and post-exposure [1].
 - 4.4.1. LAB MEDIA: Table 1. *Video editor: Highlight the rows “PBCC,” “AF,” “EESD,” “ASC,” and “RO”.*
- 4.5. Standing posture significantly enhanced Body Unencumbered Adjustment compared to seating in forest scenery [1], but not in marine scenery [2].
 - 4.5.1. LAB MEDIA: Table 2. *Video editor: Highlight the row “BUA” under the forest scenery .*
 - 4.5.2. LAB MEDIA: Table 2. *Video editor: Highlight the row “BUA” under the marine scenery .*
- 4.6. No significant differences were observed between forest and marine environments for emotional or embodiment measures [1].
 - 4.6.1. LAB MEDIA: Table 2. *Video editor: Show the forest and marine tables side by side.*
- 4.7. Forest-familiar participants reported significantly higher baseline tension [1] and total

mood disturbance compared to participants with different familiarity levels [2].

4.7.1. LAB MEDIA: Table 3. *Video editor: Highlight the row “tension”* .

4.7.2. LAB MEDIA: Table 3. *Video editor: Highlight the row “TMD”*.

4.8. Participants reported moderate levels of presence with a median of 4.208 [1], and moderate connectedness to nature in forest [2] and marine environments [3].

4.8.1. LAB MEDIA: Table 4. *Video editor: Highlight the median value 4.208 in the Presence Questionnaire section.*

4.8.2. LAB MEDIA: Table 4. *Video editor: Highlight the median value 3.29 in the row CNS Forest.*

4.8.3. LAB MEDIA: Table 4. *Video editor: Highlight the median value 3.43 in the row CNS marine.*

4.9. Simulator sickness scores were low, with a mode of zero reported for nausea [1], oculomotor disturbance [2], and disorientation, indicating good tolerance of the virtual reality experience [3].

4.9.1. LAB MEDIA: Table 4. *Video editor: Highlight the mode value 0 in the row “nausea” under “mode” column.*

4.9.2. LAB MEDIA: Table 4. *Video editor: Highlight the mode value 0 in the row “oculomotor disturbance” under “mode” column..*

4.9.3. LAB MEDIA: Table 4. *Video editor: Highlight the mode value 0 in the row “disorientation” under “mode” column..*

1. Virtual reality

Pronunciation link: <https://www.merriam-webster.com/dictionary/virtual%20reality>

IPA: /ˌvɜːr.tʃʊ.əl riˈæl.ə.ti/

Phonetic Spelling: vur·choo·uhl ree·al·uh·tee

2. Headset

Pronunciation link: <https://www.merriam-webster.com/dictionary/headset>

IPA: /ˈhedˌset/

Phonetic Spelling: hed·set

3. Render

Pronunciation link: <https://www.merriam-webster.com/dictionary/render>

IPA: /ˈren.də/

Phonetic Spelling: ren·der

4. Marine
Pronunciation link: <https://www.merriam-webster.com/dictionary/marine>
IPA: /məˈri:n/
Phonetic Spelling: muh·reen
5. Ambient
Pronunciation link: <https://www.merriam-webster.com/dictionary/ambient>
IPA: /ˈæm.bi.ənt/
Phonetic Spelling: am·bee·uhnt
6. Stereo
Pronunciation link: <https://www.merriam-webster.com/dictionary/stereo>
IPA: /ˈster.i.oo/
Phonetic Spelling: stair·ee·oh
7. Spherical
Pronunciation link: <https://www.merriam-webster.com/dictionary/spherical>
IPA: /ˈsfer.i.kəl/
Phonetic Spelling: sfer·ih·kuhl
8. Coordinate
Pronunciation link: <https://www.merriam-webster.com/dictionary/coordinate>
IPA: /koʊˈɔːr.də.nət/ (noun), /koʊˈɔːr.də.neɪt/ (verb)
Phonetic Spelling: koh·or·duh·nuht, koh·or·duh·nayt
9. Parallax
Pronunciation link: <https://www.merriam-webster.com/dictionary/parallax>
IPA: /ˈper.ə.læks/
Phonetic Spelling: pair·uh·laks
10. Questionnaire
Pronunciation link: <https://www.merriam-webster.com/dictionary/questionnaire>
IPA: /ˈkwes.tʃəˈner/
Phonetic Spelling: kwes·chuh·nair
11. Baseline
Pronunciation link: <https://www.merriam-webster.com/dictionary/baseline>
IPA: /ˈbeɪs.laɪn/
Phonetic Spelling: bays·line
12. Procedure
Pronunciation link: <https://www.merriam-webster.com/dictionary/procedure>
IPA: /prəˈsiː.dʒə/
Phonetic Spelling: pruh·see·jer
13. Immersive
Pronunciation link: <https://www.merriam-webster.com/dictionary/immersive>
IPA: /ɪˈmɜː.sɪv/
Phonetic Spelling: ih·mur·siv
14. Standardized
Pronunciation link: <https://www.merriam-webster.com/dictionary/standardize>
IPA: /ˈstæn.dəˌdaɪzd/
Phonetic Spelling: stan·der·dyzed

15. Exposure
 Pronunciation link: <https://www.merriam-webster.com/dictionary/exposure>
 IPA: /ɪkˈspoʊ.ʒə/
 Phonetic Spelling: ik·spoh·zher
16. Embodiment
 Pronunciation link: <https://www.merriam-webster.com/dictionary/embodiment>
 IPA: /ɪmˈbɑː.di.mənt/
 Phonetic Spelling: em·bod·ee·muhnt
17. Simulator
 Pronunciation link: <https://www.merriam-webster.com/dictionary/simulator>
 IPA: /ˈsɪm.jə.leɪ.tə/
 Phonetic Spelling: sim·yuh·lay·ter
18. Oculomotor
 Pronunciation link: <https://www.howtopronounce.com/oculomotor>
 IPA: /ˌɑː.kjə.loʊˈmoʊ.tə/
 Phonetic Spelling: ok·yuh·loh·moh·ter
19. Disorientation
 Pronunciation link: <https://www.merriam-webster.com/dictionary/disorientation>
 IPA: /dɪsˌɔːr.i.ənˈteɪ.ʃən/
 Phonetic Spelling: dis·or·ee·en·tay·shuhn
20. Friedman
 Pronunciation link: <https://www.howtopronounce.com/friedman>
 IPA: /ˈfriːd.mən/
 Phonetic Spelling: freed·muhn
21. Significant
 Pronunciation link: <https://www.merriam-webster.com/dictionary/significant>
 IPA: /sɪɡˈnɪf.ə.kənt/
 Phonetic Spelling: sig·nif·ih·kuhnt
22. Vigor
 Pronunciation link: <https://www.merriam-webster.com/dictionary/vigor>
 IPA: /ˈvɪɡ.ə/
 Phonetic Spelling: vig·er
23. Unencumbered
 Pronunciation link: <https://www.merriam-webster.com/dictionary/unencumbered>
 IPA: /ˌʌn.ɪnˈkʌm.bərd/
 Phonetic Spelling: un·en·kum·berd
24. Agency
 Pronunciation link: <https://www.merriam-webster.com/dictionary/agency>
 IPA: /ˈeɪ.dʒən.si/
 Phonetic Spelling: ay·juhn·see
25. Objectification
 Pronunciation link: <https://www.merriam-webster.com/dictionary/objectification>
 IPA: /əbˌdʒek.tə.fəˈkeɪ.ʃən/
 Phonetic Spelling: ub·jek·tuh·fuh·kay·shuhn

26. Familiarity
Pronunciation link: <https://www.merriam-webster.com/dictionary/familiarity>
IPA: /fəˌmɪl.iˈer.ə.ti/
Phonetic Spelling: fuh·mil·ee·air·uh·tee
27. Median
Pronunciation link: <https://www.merriam-webster.com/dictionary/median>
IPA: /ˈmiː.di.ən/
Phonetic Spelling: mee·dee·uhn
28. Connectedness
Pronunciation link: <https://www.merriam-webster.com/dictionary/connectedness>
IPA: /kəˈnek.tɪd.nəs/
Phonetic Spelling: kuh·nek·tid·nuhs
29. Nausea
Pronunciation link: <https://www.merriam-webster.com/dictionary/nausea>
IPA: /ˈnɑː.zi.ə/, /ˈnɔː.zi.ə/
Phonetic Spelling: nah·zee·uh, naw·zee·uh
30. Oculomotor disturbance
Pronunciation link: <https://www.howtopronounce.com/oculomotor>
IPA: /ˌɑː.kjə.loʊˈmoʊ.tər dɪˈstɜː.bəns/
Phonetic Spelling: ok·yuh·loh·moh·ter dih·stur·buhns