INPLASY PROTOCOL

Corresponding author:
Rita Moura

rsmaa@iscte-iul.pt

Author Affiliation:
CIS-Iscte, Iscte - Instituto Universitário de Lisboa, Lisbon, Portugal.

Review Stage at time of this submission: The review has not yet started.

Conflicts of interest:
None declared.

The effects of immersive virtual nature on psychological outcomes: A protocol for a meta-analysis

Moura, R[1]; Camilo, C[2]; Luís, S[4].

Review question / Objective: This work aims to assess the effectiveness of immersive virtual nature in promoting psychological health. To this end, the proposed meta-analysis will address the following research question: How effective is immersive virtual nature in improving affect, emotion regulation, stress, mental health, restoration, and well-being among clinical and non-clinical adults as compared to a control condition? Population: Clinical adults, non-clinical adults. Intervention: Immersive virtual nature. Comparison: Control condition. Outcomes: Affect, emotion regulation, stress, mental health (anxiety, depression), restoration, and well-being.

INTRODUCTION

Review question / Objective: This work aims to assess the effectiveness of immersive virtual nature in promoting psychological health. To this end, the proposed meta-analysis will address the following research question: How effective is immersive virtual nature in improving affect, emotion regulation, stress, mental health, restoration, and well-being among clinical and non-clinical adults as compared to a control condition? Population: Clinical adults, non-clinical adults. Intervention: Immersive virtual nature. Comparison: Control condition. Outcomes: Affect, emotion regulation,

stress, mental health (anxiety, depression), restoration, and well-being.

Rationale: The study of virtual nature has grown exponentially in recent times, with studies suggesting that it can be used for interventional purposes. However, mixed results between studies have been emerging. For example, a recent systematic review reported that some studies found that virtual nature diminished negative mood, whereas others found no change (Frost et al., 2022). We conducted a pre-search in Scopus and found two meta-analyses regarding virtual nature. First, given the significant increase in studies since 2020, the meta-analysis conducted by Browning et al. (2020) needs to be updated. Besides, this work only compared the effects between real nature and virtual nature, whereas recent studies include other control/comparison conditions (e.g., indoor, urban VR setting). Second, the meta-analysis conducted by Bolouki (2002) focused solely on affect outcomes. Yet, if virtual nature is to be used as a mental health intervention strategy, it is important to know its effectiveness in promoting other psychological outcomes. As such, there is a need for a meta-analysis to determine the effect size for different psychological outcomes, as the one proposed, and if possible, conduct new analysis to help understand the mixed results.

At this early stage, our aim is to be as inclusive as possible, so we are not limiting our searches to specific types of populations, control/comparison conditions, or study designs. Rather, we sought to find a larger number of studies so that in the course of the analyses we can group them coherently and thereby give a more integrative and realistic overview of the effectiveness of virtual nature.

Condition being studied: There is an ever-growing concern for people's psychological health and well-being, which calls for new ways of dealing with this problem beyond standard health interventions. Immersive virtual nature has been used as an innovative way to investigate and intervene in psychological health under realistic environments and controlled settings. Particularly, immersive virtual nature has been associated with positive outcomes in two ways: it buffers stress levels and negative mood and promotes positive mood and mental health, thus contributing to higher levels of psychological health and well-being.

METHODS

Search strategy: Combination of keywords: Title must include: Virtual OR VR OR immer*
All fields must include: HMD* OR head-mounted display* OR CAVE OR "CAVE system*" OR "Cave Automatic Virtual Environment". Title, abstract or keywords must include: natur* OR "nature exposure" OR "nature experience" OR "nature contact" OR "natur* space" OR environment* OR "natur* environment" OR "green space*" OR "blue space*" OR greenspace* OR bluespace* OR forest* OR park* OR garden OR beach* OR sea OR lake* OR river* OR psychology* OR affect OR mood OR emotion* OR stress* OR distress OR relaxation OR anxiety OR depression OR restoration OR fatigue OR attention* OR well-being OR "well being" OR "wellbeing" OR physiologic*

Participant or population: Clinical and non-clinical adults (i.e., 18 years old or older) enrolled in studies of immersive virtual nature will be eligible for this meta-analysis, with no exclusion based on gender or ethnicity. Studies conducted with younger populations will not be considered.

Intervention: Studies including an immersive 360º or computer-generated virtual nature simulation condition, whether of a green, blue, or mixed environment, using a head-mounted display or CAVE System will be considered. Other types of virtual simulation or devices will not be considered (e.g., AR, 3D, computer screen, TV).

Comparator: Control/comparison conditions including no intervention/

simulation (e.g., indoor), real nature, or other relevant types of immersive virtual simulations (e.g., city, buildings) will be considered.

Study designs to be included: Randomized controlled trials, non-randomized studies, and pre-posttest designs will be included. Qualitative studies and reviews will not be considered.

Eligibility criteria: Additional exclusion criteria: Articles not published in a peer-reviewed journal (grey literature), non-English articles, and articles in which is unclear what VR technology or virtual nature simulation was used.

Information sources: Databases:
- Scopus
- Web of Science
- PubMed
- PsycINFO
- PsycNET
- Cochrane Library
Other methods:
- Check published reviews
- Contact authors

Main outcome(s): Outcomes regarding affect, emotion regulation, stress, mental health (anxiety, depression), restoration, and well-being and related indicators (e.g., heart rate, skin conductance) will be considered. Self-report data and physiological data will be considered.

Data management: All studies will be exported to a reference manager, and after removing duplicates, the remaining studies will be uploaded to an online platform. Two reviewers will independently proceed with the full-text screening, and discrepancies that might arise during this process will be resolved by the third reviewer. Data will be independently extracted from eligible studies by two reviewers using the same data table, including the following information: study information (author, publication year, country), study design, sample (sample size, age), VR equipment, intervention (type, duration, frequency), control (type, duration, frequency),

outcome measures. The extracted data will be cross-checked by the third reviewer.

Quality assessment / Risk of bias analysis: Two reviewers will independently proceed with the assessment of the methodological quality of the included studies. Disagreements will be resolved by the third reviewer. The following tools will be used to conduct this analysis:
- Cochrane risk-of-bias tool for randomized trials (RoB 2)
- Risk of bias in non-randomized studies of interventions (ROBINS-I).

Strategy of data synthesis: The analyses will be conducted using SPSS v28. Data from the eligible studies will be presented in a summarized table, including descriptive statistics. A forest plot will be generated with the outcomes, with a 95% confidence interval. Interstudy heterogeneity will be assessed using Cochran's Q test ($p < 0.10$ for statistical significance) and quantified with an I2 statistic ($I^2 > 50\%$ used as a threshold for significant heterogeneity). Heterogeneity will be considered low, moderate, and high when the values are below 25%, between 25% and 75%, and above 75%, respectively. The publication bias will be assessed with a funnel plot and tested with Egger's weighted regression analysis. When a bias is found, we will conduct a Duval and Tweedie non-parametric "trim and fill" analysis.

Subgroup analysis: If the data collected allow it, we will conduct subgroup analyses. The decision regarding which subgroups will be made after gathering and analyzing the data.

Sensitivity analysis: To measure the robustness of the studies' results we will conduct a sensitivity analysis with the Leave-one-out Jackknife sensitivity analysis approach.

Language restriction: English.

Country(ies) involved: Portugal.

Other relevant information: The second organizational affiliation is HEI-Lab, Universidade Lusófona, Lisbon, Portugal (Campo Grande, 376, 1749-024 Lisboa, Portugal).

Keywords: Virtual nature; virtual reality; affect; stress; mental health; restoration; well-being; meta-analysis.

Contributions of each author:
Author 1 - Rita Moura - Conceiving the review; Designing the review; Coordinating the review; Data collection; Data management; Analysis of data; Interpretation data; Writing the protocol; Writing review.
Author 2 - Cristina Camilo - Conceiving the review; Designing the review; Coordinating the review; Data collection; Data management; Analysis of data; Writing the protocol; Writing review.
Author 3 - Sílvia Luís - Conceiving the review; Designing the review; Coordinating the review; Data collection; Data management; Interpretation data; Writing the protocol; Writing review.

References:
Bolouki A. The impact of virtual reality natural and built environments on affective responses: A systematic review and meta-analysis. Int. J. Environ. Health Res. 2022: 1-17.
Browning MHEM, Shipley N, McAnirlin O, Becker D, Yu CP, Hartig T, Dzhambov AM. An actual natural setting improves mood better than its virtual counterpart: A meta-analysis of experimental data. Front Psychol. 2020; 11:2200.
Frost S., Kannis-Dymand L, Schaffer V, Millear P, Allen A, Stallman H, et al. Virtual immersion in nature and psychological well-being: A systematic literature review. J. Environ. Psychol. 2022; 80:101765.