

ORIGINAL ARTICLE



Olfactory Virtual Reality (OVR) for Wellbeing and Reduction of Stress, Anxiety and Pain

David Tomasi , PhD,EdD-PhD,MMed,MA,MCS,AAT,GT1* | Hannah Ferris, MS 2 | Priscilla Booraem, MS, GT 3 | Lindsay Enman, MSW,GT4 | Sheri Gates, MA, GT5 | Emily Reyns, MA, R-DMT, MHC, GT6

¹University of Vermont Integrative Health, College of Nursing and Health Sciences, Department of Rehabilitation and Movement Science; University of Vermont Continuing and Distance Education, UVM Healthcare Programs ; University of Vermont Human Development and Family Studies Program, Department of Leadership & Developmental Sciences; University of Vermont Medical Center, Inpatient Psychiatry; Community College of Vermont

²University of Vermont Larner College of Medicine, Department of Pharmacology; University of Vermont; University of Vermont Medical Center

^{3,4,5}University of Vermont Medical Center, Inpatient Psychiatry

⁶University of Vermont Integrative Health, College of Nursing and Health Sciences; University of Vermont Medical Center, Inpatient Psychiatry;



Abstract

Background: As part of a consistent effort to examine and provide integrative medical approaches to the therapeutic offering for psychophysical health, this study investigates the utilization of Olfactory Virtual Reality (OVR) in an inpatient psychiatry unit, more specifically in the Shepardson 3 Inpatient Psychiatry Unit at the University of Vermont Medical Center, in Burlington, VT, USA.

Objectives: The purpose of this protocol is to explore the therapeutic value of olfactory virtual reality (OVR) in the above described population, and to collect statistically significant data to determine the feasibility of potential future OVR studies.

Method: Direct subject observation and monitoring in the context of Olfactory Virtual Reality (OVR) sessions and Qualitative data collection via the administration of subject surveys, subdivided in: a) Pre-OVR experience, b) Immediate post-OVR experience, and c) 1-to-3-hour post-OVR experience questionnaires.

Results: The research yielded positive outcomes in all areas investigated, despite challenges related to the utilization of the device itself, issues in individual olfactory threshold, and COVID-19 restrictions and limitations.

Conclusion: The outcome of this study indicates that the utilization of olfactory virtual reality technologies is a safe and effective integrative approach to target several aspects of psychological and physical health such as anxiety, stress, and pain, in combination with the psychotherapeutic and pharmacological standards of care in inpatient psychiatry.

Keywords: Medicine, Neuroscience, Virtual Reality, Olfactory System, Stress, Anxiety, Pain, Psychiatry, Psychology

Copyright : © 2021 The Authors. Published by MRER Publisher Ltd. This is an open access article under the CC BY-NC-ND license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>).

1 | INTRODUCTION

The goal of this study is to use an *OVR-Technology*-developed Virtual and Altered Reality (VAR) device (Image 1) that includes an olfactory stimulation (scent) component in addition to the traditional visual component of virtual reality. (1),(2),(3) The OVR sessions engineered for this research protocol were focused on creating a more immersive, realistic, evocative, meaningful, and emotional VAR experience, and by allowing for the subjects enrolled therein to enter a calming and realistic environment, in order to decrease the amount of anxiety, stress, and pain experienced by study subjects. In multiple studies, the utilization of Virtual reality-based technologies has proven to be a useful tool in a range of medical issues connected with psycho-physical challenges including, but not limited to, distraction for pain and medical procedures, relaxation and calming, and immersion therapy for trauma, PTSD and phobias. (4), (5),(6),(7),(8),(9),(10),(11) Certainly, there are significant challenges and potential dangers in the utilization of digital-virtual technologies (with significant differences among the specific types of technology examined), often associated with decrease in cognitive and emotional capacity and understanding, focus vs. attention, as well as possible addictive properties of this type of intervention. (12),(13),(14),(15),(16) These aspects are particularly relevant in a vulnerable population such as the one examined in this particular study, i.e. inpatient psy-chiatry patients.

However, due to the documented relationships between scent, memory, and emotion (17),(18),(19), (20),(21),(22) the authors of this study wanted to verify the possible benefits of adding an olfactory stimulation component, following the current scientific evidence on emotion, cognition, attention, and memory in general, and more in detail on specific neural areas such as the olfactory-related afferents and efferents of the mediodorsal thalamic nucleus (MDT), (23),(24),(25) to the virtual reality component of the experience, thereby monitoring the potential to increase the immersion and presence of such virtual environments, and to create a more therapeutically appropriate and nurturing emotional

connection, in the broader context of wellbeing and health.

2 | INTERVENTION

General Description

The OVR environment is an immersive, 3-dimensional, 6 DoF (Six Degrees of Freedom) environment in which the subject can freely move and interact with the virtual items presented therein (e.g. campfire, marshmallows, sticks/logs wood), flowers, citronella candles, bacon, tree bark, soda-cola, with ambient scent of forest, as well as natural environment sounds such as leaves, etc.), to recreate a reality-like environment (Image 3). The "safety range" of approximately 10ft x 10ft in the selected study room has been cleared of any objects or furniture, so that subjects may move through the environment safely. These borders are defined by invisible walls in the OVR software, when the patient gets close to the edge of this safety range. More specifically, the environment is designed to simulate a relaxing camping experience including a tranquil campsite, tent, picnic table and fire pit cluster at the edge of rocks and trees overlooking the sunset. There are many objects in the OVR environment that the subject can interact with using two hand-held wands (*virtual hands*). These wands are tracked through HMD (head-mounted display)-mounted sensors to correspond with their movements and have buttons and grips that allow the user to interact with items (Image 2). As the subject moves about and interacts with the environment, corresponding odors connected to the general environment as well as specific items and interactions are precisely released to give the environment an enhanced perception vs. proprioception of presence. Each subject spent on average 10 minutes in the OVR environment before the Inpatient psychiatry Group therapist (GT)

Supplementary information The online version of this article (<https://doi.org/10.15520/jmrhs.v4i3.322>) contains supplementary material, which is available to authorized users.

Corresponding Author: *David Tomasi*

OLFACTORY VIRTUAL REALITY (OVR) FOR WELLBEING AND REDUCTION OF STRESS, ANXIETY AND PAIN

assisted the patient in removing the Head-Mounted Display (HMD).

Primary Workflow and Timeline

This research study has been conducted over a 4-month period with Inpatient Psychiatry subjects (N= 60). Each patient participated in 2 sessions per week for a minimum of 2 weeks (with data being considered admissible after 2 sessions). Data have been recorded from each patient before, during, and after each session through Pre-, Immediate Post- and 1-to-3 hours Post- Questionnaires. After initial brief explanation, the clinician (Psychotherapist / Group Therapist) assisted the subject in securing the OVR/HMD device. More specifically, the HMD in this test was a Samsung Odyssey. This is a display device, worn on the head that covers both eyes and is secured via straps. The OVR device is mounted to the bottom of the mask and sits near the nose without making any skin contact to the user. As soon as the HMD is secured the clinician handed the subject the wands and ensured that they are comfortable. After this procedure has been completed, the OVR experience/session began through activation on a connected computer. Subjects have been monitored as they experienced the environment to ensure the absence of technical and/or clinical-medical issues and had the ability to turn off the environment from the connected computer at any time. After 8 to 12 minutes, at the conclusion of the OVR experience/session, the GT helped each subject individually remove the HMD and secure the device nearby, and turn off the environment via the attached computer. Following each session/single patient use, the device has been sanitized and examined for any loose connections or issues. The environment has then been rebooted in preparation of the next session with a new subject.

3 | METHODS

Population and Eligibility

The subjects examined in this study were adult patients (18 and above, N=60) on the inpatient psychiatry unit Shepardson 3, University of Vermont Medical Center (UVMCC), over a 4-month study

period (September-December 2020). More specifically, UVMCC Shepardson 3 presents a patient population with DSM-5 psychiatric diagnoses ranging from PTSD and other traumas, MDD, Bipolar Affective Disorder(s) (BPAD I vs II), Cluster A, B, and C Personality Disorders, other mood disorders, as well as Adjustment- and Generalized Anxiety Disorders, often in combination with other specified/unspecified psychiatric vs. general medical issues and comorbidities.

Qualitative and Quantitative Analysis

The pre-, immediate post-, and 1-to-3-hour post-session surveys addressed anxiety and stress levels, emotional and physical pain, psychological state, overall mood, level of enjoyment during the session, using a combination of binary (Yes/No) responses and Likert scales, with reported percentages and p-value from McNemar test and p-value from Wilcoxon Signed-Rank, in combination with open-ended question about the overall experience as subjectively perceived by the subject. The complete list of questions in the surveys administered to patients, with relative percentages and statistically relevant annotations, is reported in *Section C - Questionnaires (1,2 and 3)* respectively.

Inclusion Criteria

At the beginning of each OVR session, the Group Therapist read the informed consent information and procedure to the patients. Following informed consent documentation, every patient had the option to decline to take part in the exercise and nutrition education group.

Withdrawal Procedures

Following informed consent documentation, every patient had the option to decline session attendance, and to fill out the research survey.

Subjects had been allowed to withdraw from the study at any time, knowing that withdrawing from the study will have no impact on their clinical care. PI and multidisciplinary treatment team members (PhD, PsyD, MA, MD, MS, and MSW) assessed subjects to determine whether to withdraw subjects when clinically/medically inappropriate circumstances arise.

Safety, Privacy and Consent

All the information has been collected without any identifiers and used only for statistical purposes, and it will not be connected or linkable to clinical/medical records of single patients and/or groups / categories / diagnosis in the future. The hardcopy data has been archived in the locked group Therapist Office on Shepardson 529, separated from both Inpatient Psychiatry Units Shepardson 3 and Shepardson 6. Each GT documented on paper the number of subjects participating in the session and the number of subjects absent or subjects who declined to take part in the group.

4 | RESULTS

Positive Aspects

Examining the data obtained by analyzing subjects' responses in the administered pre-, immediate post-, and 1-to-3-hour post-session surveys, the researchers have been able to identify multiple positive outcomes as direct results of the implementation of Olfactory Virtual Reality in Inpatient Psychiatry. Of note, as the study-related OVR sessions have been offered in combination with the pre-existing integrative therapeutic offerings conducted by the UVMC psychotherapists / group therapists as part of the weekly schedule, (26), (27) all the subjects/patients involved in this research had the opportunity to further discuss their experiences in a nurturing, supportive and clinically appropriate environment for the whole duration of their admission, thereby providing them with constant opportunities for processing and cognitive, emotional improvement and overall well-being.

More specifically, the data yielded positive results across the spectrum of psycho-physical areas investigated. Utilizing a 1-10 scale (1-lowest, 10-highest value), *Anxiety* levels of 9 (16.2 %) or 10 (29.4 %) in the *Before* session, reported 1.8 % and 0 % respectively in the *Immediately After* session, and 0 % and 0% in the *1-to-3 hours After* session, with a Relative Difference of -1.0 in both cases (Figure 1a). Similarly significant values were observed in the *Stress* area, with levels of 9 (16.4 %) and 10 (36.1 %) in the *Before* Session, 3.6 % and 0 % respectively in the *Immediately After* Session, and

5.0 % and 0% in the *1-to-3 hours After* session with a Relative Difference of -0.7 for value 9 and -1.0 for value 10 (Figure 2b). For the *Pain*-related responses, the values were 6.6 % in both 9 and 10 in the *Before* Session, 0 % and 0 % respectively in the *Immediately After* Session, and 0 % and 0% in the *1-to-3 hours After* session, with a Relative Difference of -1.0 in both cases (Figure 3a).

As observed in figures (Figure 1b, Figure 2b and Figure 3b) the overall improvement (i.e. significant decrease) in these three areas was observed through-out the response provided. Subjects answering the question "Is there anything bothering you today (mental or physical)" also selected their response on the same 1-10 scale (1-lowest, 10-highest value) in the case of a positive ("yes") answer (Questionnaires 1, 2, and 3). The results yielded were 23 % for level 9 and 23 % for level 10 in the *Before* Session, with a significant decrease in the *Immediately After* Session, with 7.0 % for both value 9 and 10, and 0.0 % for both value 9 and 10 in the *1-to-3 hours After* session (Figure 4b). The Relative Difference to the same question in the comparison between *Before*, *Immediately After*, and *1-to-3 hours After* Session yielded a 0.2 for "Yes" and 10.5 for "No" (Table 1). For the question "Did you enjoy the virtual reality experience?" the values observed were 0.02 for "Yes" and -1.0 for "No" (Table 2).

While these results are very significant, it is also important to note the impact of the decrease in the psychological factors in the context of complex diagnostic medical-psychiatric presentations, particularly in inpatient psychiatry. In this sense, multiple studies have also indicated that an overall amelioration of psychological wellbeing has resulted in an improvement of physical factors. (28),(29),(30), (31) This is evidenced by the results presented in (Figure 5, Figure 6, Figure 7) with an overall significant decrease in the levels of anxiety and stress and the broader, *bio-psycho-social* model-based area investigated by the question "Is there anything bothering you today (mental or physical)." The aforementioned data thus indicated that Olfactory Virtual Reality, in conjunction with standard-of-care psychotherapeutic and pharmacological interventions, significantly resulted in a reduction of the subject-reported values for anxiety, stress and pain.

OLFACTORY VIRTUAL REALITY (OVR) FOR WELLBEING AND REDUCTION OF STRESS, ANXIETY AND PAIN

Negative Aspects

Some of the challenges encountered during the study were related to technical glitches and/or to the utilization of the VAR device itself, which proved to be somewhat difficult to utilize by the elder subjects in the study population examined. As an example of the above, once the subject already started the OVR process, if they had pressed on any other button on the “joystick/virtual hand” and they inadvertently exited the program, the software would open a new sub-menu, thus requiring, at times, the process to be started anew. Some more specific challenges were related to the medical presentation of the subject undergoing the OVR experience, for instance in regard to the need to re-adjust the virtual perimeter/boundaries and height for subjects who were experiencing the VAR scenario on a wheelchair (the VR cable often got stuck either under the wheels or the oxygen cylinder). Another potential issue lied in the very nature of the study presented, i.e. some decreased scores in olfactory threshold experienced by subjects affected by depressive disorders, as evidenced in multiple studies. (32),(33),(34) Of note, while similar clinical presentations regarding olfaction have been observed in COVID-19-positive individuals, all subjects who undertook this research study have been testing negative for SARS-Cov-2 Test prior to their admission to the Inpatient Psychiatry Unit Shepardson 3, where the study was conducted.

The current COVID-19 pandemic had of course added challenges, particularly in terms of the allotted number of subjects allowed in the OVR session room at any given time (N=1 + GT) and the required implementation of safety & hygiene restrictions, which contributed to the slowing down of the examination process in general.

5 | CONCLUSIONS

Mounting evidence from current scientific research warrants the need for incorporating integrative methods to improve clinical outcomes across a wide range of physical and mental health disorders. (35), (36),(37),(38),(39),(40),(41),(42),(43) Certainly, an

attentive investigation of the specific approaches within integrative therapeutic modalities is warranted, especially in the context of the complexity of psycho-physical clinical presentations of individuals in an inpatient psychiatry unit. The results of this study indicates that the utilization of an integrative approach focused on olfactory virtual reality technologies *in addition to* the evidence-based standards of care within psychotherapy and pharmacology is a safe and effective strategy to target several aspects of psychological and physical health such as anxiety, stress, and pain.

Beside the observed decrease in self-reported levels of anxiety, stress, and pain, an important factor at the center of the application of olfactory virtual reality in inpatient psychiatry is its ability to provide an immersive psychological, physical, and (albeit to a lesser extent given the added restrictions of both technology and safety measures) social experience to those patients who are otherwise unable to engage in other integrative approaches to care, such as physical exercise, gentle movement or stretching, Yoga and T'ai Chi Chuan, Music Therapy or Dance Movement Therapy, due to physical problems or other medical comorbidities. This is especially true in the context of the current COVID-19 the pandemic which contributes to further self-isolation, a significant problem affecting, and in turn, affected, by a vast range of psychological issues, particularly depressive states and traumas. In other words, where physical proximity is not possible and or allowed, this type of technology allows the individual to experience a re-created environment in a safe, monitored, and measurable way.

Furthermore, the ability of the olfactory-visual stimulation provided by OVR to positively affect emotion and memory can be an important aide and support in the complex process of mitigating the negative effects of the aforementioned psychological and social issues (e.g. MDD, PTSD, as well as Addiction disorders, etc.) affecting such vulnerable populations and could promote a better understanding of the psychological functioning in the general public during a times of epidemiological challenges and increased risks for further medical and psychological problems.

6 | LIMITATIONS AND FUTURE STUDIES

The primary limitations of this study are the specific population investigated, the total number of participants, the limited technical glitches encountered during the setting up portion of the OVR session, the specific challenges linked to the diagnostic presentation of the subjects examined, and the limitations in terms of clinical safety and exposure parameters for clinical research subjects, following COVID-19 taskforce recommendations. Future EBM double-blind RCTs and biostatistical-epidemiological analysis are recommended to verify the empirical validity of the results and outcomes discussed herein.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for authorship, and/or publication of this article.

Acknowledgments

Gratitude extended to all staff, students, faculty at the University of Vermont Medical Center and the University of Vermont.

Images

A) General Results

Percent (%) of participants reporting level of Anxiety

Timing of Survey	Level (1 - lowest, 10 - highest)										median
	1	2	3	4	5	6	7	8	9	10	
Before	1.5	2.9	4.4	10.3	4.4	13.2	5.9	11.8	16.2	29.4	8
Immediately After	21.4	23.2	21.4	12.5	7.1	8.9	1.8	1.8	1.8	0	3**
1-3h After	12.5	25	25	17.5	10	5	0	5	0	0	3**
Relative difference	7.5	7.5	4.7	0.7	1.3	-0.6	-1.0	-0.6	-1.0	-1.0	

**p < 0.001

Figure 1a.

The Wilcoxon Signed Rank test was completed between the Before and Immediately After time points, $z = -6.528$, $p < 0.001$ and the Before and 1-3h After time points, $z = -5.550$, $p < 0.001$.

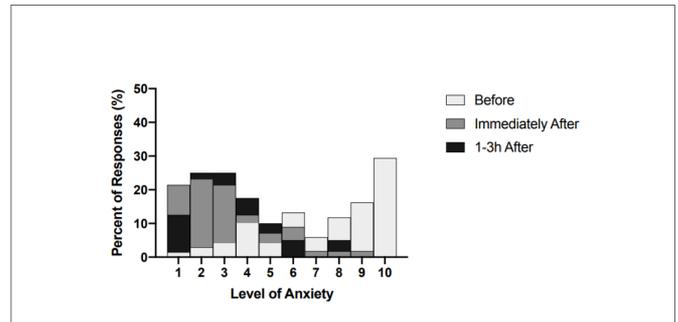


Figure 1b. Time point comparison in percent of responses per level of Anxiety subdivided into Before, Immediately After, and 1-to-3 hours-After

Percent (%) of participants reporting level of Stress

Timing of Survey	Level (1 - lowest, 10 - highest)										median
	1	2	3	4	5	6	7	8	9	10	
Before	1.6	3.3	4.9	9.8	9.8	3.3	4.9	9.8	16.4	36.1	9
Immediately After	21.8	25.5	21.8	9.1	9.1	3.6	3.6	1.8	3.6	0.0	3**
1-3h After	15.0	25.0	25.0	5.0	7.5	10.0	2.5	5.0	5.0	0.0	3**
Relative difference	8.1	6.6	4.1	-0.5	-0.2	2.0	-0.5	-0.5	-0.7	1.0	

**p < 0.001

Figure 2a.

The Wilcoxon Signed Rank test was completed between the Before and Immediately After time points, $z = -6.437$, $p < 0.001$, and the Before and 1-3h After time points, $z = -5.415$, $p < 0.001$.

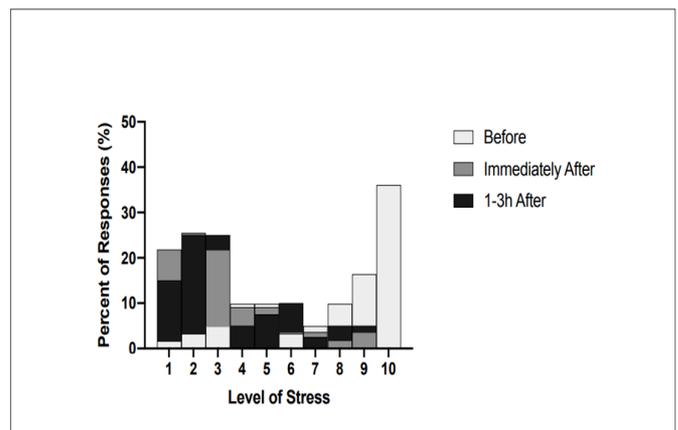


Figure 2b.: Time point comparison in percent of responses per level of Stress subdivided into Before, Immediately After, and 1-to-3 hours-After

OLFACTORY VIRTUAL REALITY (OVR) FOR WELLBEING AND REDUCTION OF STRESS, ANXIETY AND PAIN

Percent (%) of participants reporting level of Pain

Timing of Survey	Level (1 - lowest, 10 - highest)										median
	1	2	3	4	5	6	7	8	9	10	
Before	21.3	16.4	11.5	21.3	3.3	3.3	4.9	4.9	6.6	6.6	4
Immediately After	37.8	24.4	6.7	8.9	4.4	6.7	4.4	6.7	0.0	0.0	2
1-3h After	21.9	18.8	18.8	9.4	9.4	9.4	9.4	3.1	0.0	0.0	3**
Relative difference	0.0	0.1	0.6	-0.6	1.9	1.9	0.9	-0.4	-1.0	-1.0	

** p < 0.001

Figure 3a

The Wilcoxon Signed Rank test was completed between the Before and Immediately After time points, $z = -1.534$, $p = 0.125$, and the Before and 1-3h After time points, $z = -4.439$, $p < 0.001$.

Figure 3b

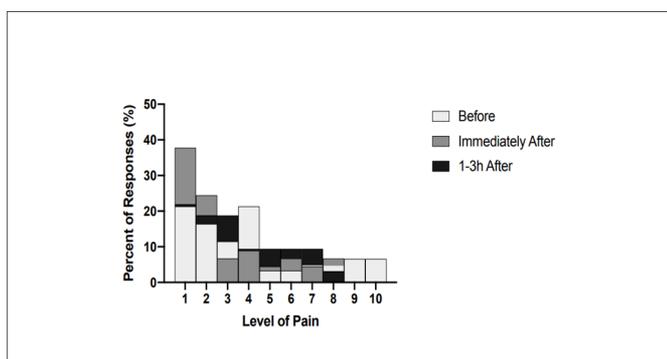


Figure 3b : Time point comparison in percent of responses per level of Pain subdivided into Before, Immediately After, and 1-to-3 hours-After

Percent (%) of participants reporting level of "Anything bothering [you]"

Timing of Survey	Level (1 - lowest, 10 - highest)										median
	1	2	3	4	5	6	7	8	9	10	
Before	3.3	1.6	1.6	6.6	3.3	8.2	13.1	16.4	23.0	23.0	8
Immediately After	11.6	9.3	30.2	11.6	14.0	7.0	4.7	4.7	7.0	0.0	3**
1-3h After	4.0	16.0	20.0	16.0	20.0	8.0	8.0	8.0	0.0	0.0	4**
Relative difference	0.2	8.8	11.2	1.4	5.1	0.0	-0.4	-0.5	-1.0	-1.0	

** p < 0.001

Figure 4a

The Wilcoxon Signed Rank test was completed between the Before and Immediately After time points, $z = -5.452$, $p < 0.001$, and the Before and 1-3h After time points, $z = -3.759$, $p < 0.001$.

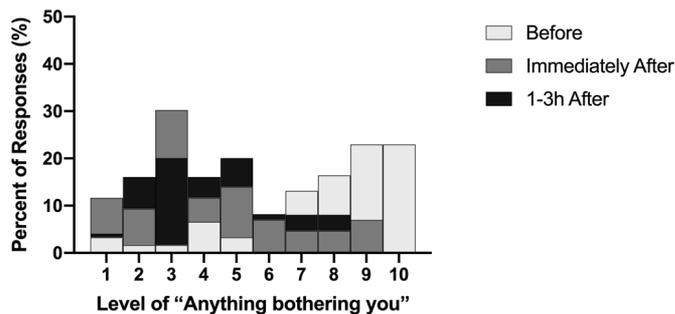


Figure 4b: Time point comparison in percent of responses per level of Anything bothering [you] subdivided into Before, Immediately After, and 1-to-3 hours-After

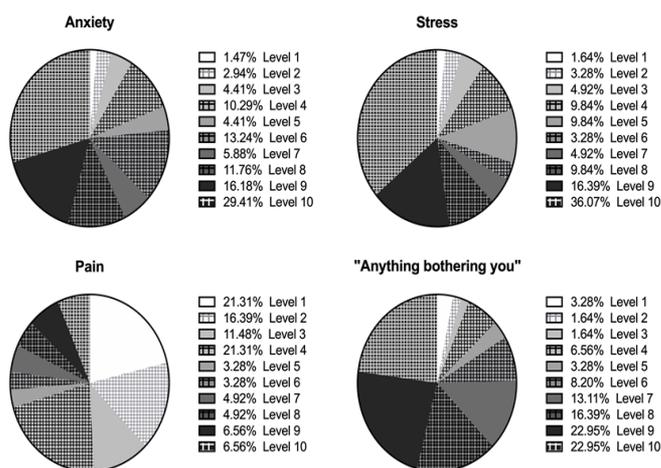


Figure 5: Pie Charts of responses Before OVR session, per level of Anxiety, Stress, Pain, and Anything bothering [you] in Percent (%).

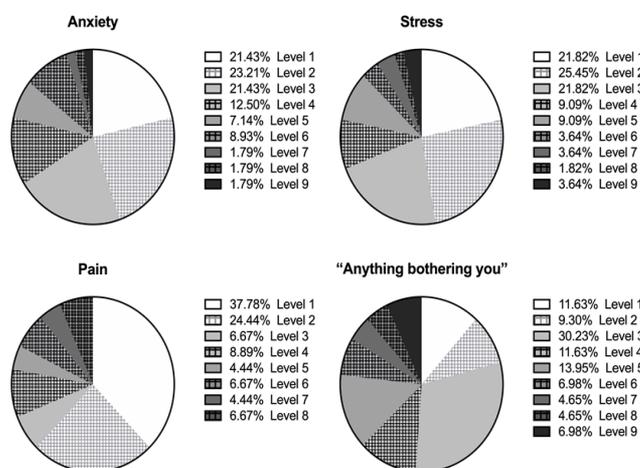


Figure 6: Pie Charts of responses Immediately After OVR session, per level of Anxiety, Stress, Pain, and Anything bothering [you] in Percent (%).

Missing levels have values = 0.

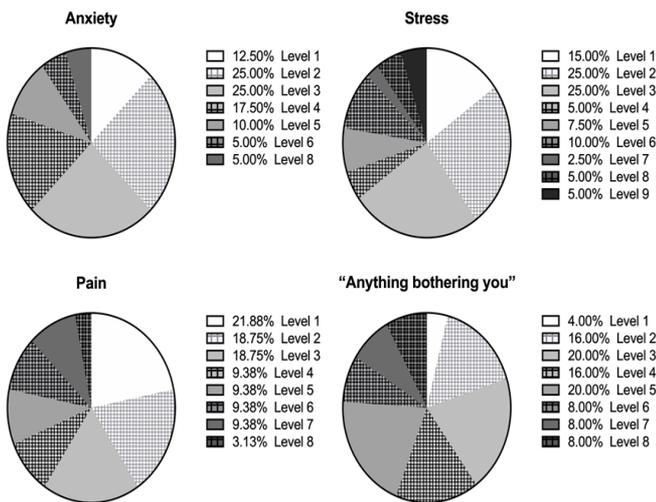


Figure 7: Pie Charts of responses 1-to-3 Hours After OVR session, per level of Anxiety, Stress, Pain, and Anything bothering [you] in Percent (%).

Missing levels have values = 0.

B) Comparative Tables

Table 1.

Percent (%) of responses to “Is anything bothering you today?” Before, Immediately After, 1-to-3 hours After, and relative difference

Timing of Survey	Yes	No	p value
Before	98.3	1.7	
Immediately After	82.1	17.9	0.002
1-3h After	80.5	19.5	0.008
Relative difference	0.2	10.5	

The McNemar test was completed between the Before and Immediately After responses, N = 56, p = 0.002, and the Before and 1-3h After responses, N = 41, p = 0.008.

Table 2.

Percent (%) of responses to “Did you enjoy the virtual reality experience?” Before, Immediately After, 1-to-3 hours After, and relative difference

Timing of Survey	Yes	No	p value
Immediately After	98.1	1.9	
1-3h After	100	0	ns
Relative difference	0.02	-1.0	

The McNemar test was completed between the Immediately after and 1-3 hours after responses, N = 38, p = 1.000.

C) Questionnaires

BEFORE undergoing virtual reality experience:

- Please indicate the level of your ANXIETY by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your STRESS by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your PAIN by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Is there anything bothering you today (mental or physical)?

YES NO
- If yes

1 2 3 4 5 6 7 8 9 10

Questionnaire 1. The pre-session survey

IMMEDIATELY AFTER undergoing virtual reality experience:

- Please indicate the level of your ANXIETY by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your STRESS by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your PAIN by circling the number that best corresponds with how you are feeling right now; 1 being the lowest level and 10 being the highest level.

1 2 3 4 5 6 7 8 9 10
- Is there anything bothering you today (mental or physical)?

YES NO
- If yes

1 2 3 4 5 6 7 8 9 10
- Did you enjoy the virtual reality experience?

YES NO

If yes, how much, on a scale of 1 to 10, 1 being very little and 10 being extremely, how much did you enjoy it?

1 2 3 4 5 6 7 8 9 10

If no, what bothered you about it?

Questionnaire 2. The immediate post-session survey.

OLFACTORY VIRTUAL REALITY (OVR) FOR WELLBEING AND REDUCTION OF STRESS, ANXIETY AND PAIN

1-TO-3 HOURS AFTER undergoing virtual reality experience:

- Please indicate the level of your ANXIETY by circling the number that best corresponds with how you are feeling right now, 1 being the lowest level and 10 being the highest level.
1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your STRESS by circling the number that best corresponds with how you are feeling right now, 1 being the lowest level and 10 being the highest level.
1 2 3 4 5 6 7 8 9 10
- Please indicate the level of your PAIN by circling the number that best corresponds with how you are feeling right now, 1 being the lowest level and 10 being the highest level.
1 2 3 4 5 6 7 8 9 10
- Is there anything bothering you today (mental or physical)?
YES NO
- If yes
1 2 3 4 5 6 7 8 9 10
- Did you enjoy the virtual reality experience?
YES NO
If yes, how much, on a scale of 1 to 10, 1 being very little and 10 being extremely, how much did you enjoy it?
1 2 3 4 5 6 7 8 9 10
If no, what bothered you about it?

Did wearing the virtual reality equipment cause any issues to your relaxation level?

Was the scent too overpowering or obvious (if applicable)?

Was the session too long? Too short? Do you have any other comment?



Image 1: The HMD-mounted ION on-mask, wifi / USB scent Device, Headset, Cartridges (foreground) and scent extracts (background) developed by OVR Technology. The Architecture of Scent® framework translates VR movements and inputs into real-time scent output, allowing for .1 millisecond bursts of scent and change between scents in 20 milliseconds.



Image 2: Frontal view of the installed version of the HMD-mounted ION on-mask, wifi / USB scent Device, Headset, and Cartridges utilized in this study.



Image 3: A Virtual reality scenario / 3D rendering developed by OVR Technology utilized in this study.

Questionnaire 3. The 1-to-3-hour post-session survey

D) Patients' Narratives

Did you enjoy the virtual reality experience?

- "This is so relaxing"
- "I feel I am in a different world, and the colors are beautiful"
- "I like that everything is so peaceful in here."
- "This is almost like a trip, but without the side effects"
- "Wow, I thought I would feel dizzy, but I feel quite comfortable"
- "The scent is so real, amazing!"

If no, what bothered you about it?

- "The scent was a little too strong at times"
- "I couldn't smell much this time."

Did wearing the virtual reality equipment cause any issues to your relaxation level?

- "Positively improving relaxation"

Was the scent too overpowering or obvious (if applicable)?

- "No, it was right on!"
- "The scents were fantastic."

Was the session too long? Too short? Do you have any other comment?

- "Too short, I really enjoyed it. I felt like I took a real break from my problems – the addition of smell was so soothing."
- "It was novel, enjoyable. I was excited to play in it. I could see potential for relaxation if I were to do it again."

Table 4. Subjects' Narratives (Abstracts)

E) Software and Hardware

REFERENCES

1. Amores J, Richer R, Zhao N, Maes P, Eskofier B. Promoting relaxation using virtual reality, olfactory interfaces and wearable EEG. In: 2018 IEEE 15th International Conference on Wearable and Implantable Body Sensor Networks (BSN); 2018. p. 98–101.
2. Micaroni L, Carulli M, Ferrise F, Gallace A, Bordegoni M. An Olfactory Display to Study the Integration of Vision and Olfaction in a Virtual Reality Environment. *Journal of Computing and Information Science in Engineering*. 2019;19(3):31015–31015. Available from: <https://dx.doi.org/10.1115/1.4043068>. doi:10.1115/1.4043068.
3. OVR Technology presentation, research and description, retrieved 1.28.2021 from <https://ovrtechnology.com/>
4. Cieřlik B, Mazurek J, Rutkowski S, Kiper P, Turolla A, Szczepańska-Gieracha J. Virtual reality in psychiatric disorders: A systematic review of reviews. *Complementary Therapies in Medicine*. 2020;52:102480–102480. Available from: <https://dx.doi.org/10.1016/j.ctim.2020.102480>. doi:10.1016/j.ctim.2020.102480.
5. Pourmand A, Davis S, Marchak A, Whiteside T, Sikka N. Virtual Reality as a Clinical Tool for Pain Management. *Current Pain and Headache Reports*. 2018;22(8):53–53. Available from: <https://dx.doi.org/10.1007/s11916-018-0708-2>. doi:10.1007/s11916-018-0708-2.
6. Abhinav RP, Sweta VR, Ramesh A. Role of virtual reality in pain perception of patients following the administration of local anesthesia. *Annals of Maxillofacial Surgery*. 2019;9(1):110–110. Available from: https://dx.doi.org/10.4103/ams.ams_263_18. doi:10.4103/ams.ams₂₆₃₁₈.
7. Fodor LA, Coteș CD, Cuijpers P, Ștefan Szamoskozi, David D, Cristea IA. The effectiveness of virtual reality based interventions for symptoms of anxiety and depression: A meta-analysis. *Scientific Reports*. 2018;8(1):10323–10323. Available from: <https://dx.doi.org/10.1038/s41598-018-28113-6>. doi:10.1038/s41598-018-28113-6.
8. Rizzo AS, Shilling R. Clinical Virtual Reality tools to advance the prevention, assessment, and treatment of PTSD. *European Journal of Psychotraumatology*. 2017;8(sup5):1414560–1414560. Available from: <https://dx.doi.org/10.1080/20008198.2017.1414560>. doi:10.1080/20008198.2017.1414560.
9. Hassan C, Antonelli G. 2020) ‘I want to have virtual reality distraction during my colonoscopy!’ *Endoscopy International Open*;08(10):1389–1391.
10. Wittkopf PG, Lloyd DM, Coe O, Yacoobali S, Billington J. The effect of interactive virtual reality on pain perception: a systematic review of clinical studies. *Disability and Rehabilitation*. 2020;42(26):3722–3733. Available from: <https://dx.doi.org/10.1080/09638288.2019.1610803>. doi:10.1080/09638288.2019.1610803.
11. Gebara CM, de Barros-Neto TP, Gertsenchtein L, Lotufo-Neto F. Virtual reality exposure using three-dimensional images for the treatment of social phobia. *Revista Brasileira de Psiquiatria*. 2015;38(1):24–29. Available from: <https://dx.doi.org/10.1590/1516-4446-2014-1560>. doi:10.1590/1516-4446-2014-1560.
12. Sabelman EE, Lam R. The real-life dangers of augmented reality. *IEEE Spectrum*. 2015;52(7):48–53. Available from: <https://dx.doi.org/10.1109/mspec.2015.7131695>. doi:10.1109/mspec.2015.7131695.
13. Kenwright B. Virtual Reality: Ethical Challenges and Dangers [Opinion]. *IEEE Technology and Society Magazine*. 2018;37(4):20–25. Available from: <https://dx.doi.org/10.1109/mts.2018.2876104>. doi:10.1109/mts.2018.2876104.
14. Sharma A, Bajpai P, Singh S, Khatter K. *Virtual Reality: Blessings and Risk Assessment, Human-Computer Interaction (cs.HC)*. Ithaca, NY; 2017.

OLFACTORY VIRTUAL REALITY (OVR) FOR WELLBEING AND REDUCTION OF STRESS, ANXIETY AND PAIN

15. López AU, Mateo F, Navío-Marco J, Martínez-Martínez JM, Gómez-Sanchís J, Vila-Francés J, et al. Analysis of computer user behavior, security incidents and fraud using Self-Organizing Maps. *Computers & Security*. 2019;83:38–51. Available from: <https://dx.doi.org/10.1016/j.cose.2019.01.009>. doi:10.1016/j.cose.2019.01.009
16. Hicks TM. Digital Detox - Addressing the Issue of Screen Addiction in Millennials” (2019). Undergraduate Honors Theses. Paper 513. <https://dc.etsu.edu/honors/513>; 2019. Available from: <https://dc.etsu.edu/honors/513>.
17. Croy I, Hummel T. Olfaction as a marker for depression. *Journal of Neurology*. 2017;264(4):631–638. Available from: <https://dx.doi.org/10.1007/s00415-016-8227-8>. doi:10.1007/s00415-016-8227-8.
18. Abramowitz EG, Lichtenberg P. Hypnotherapeutic Olfactory Conditioning (HOC): Case Studies of Needle Phobia, Panic Disorder, and Combat-Induced PTSD. *International Journal of Clinical and Experimental Hypnosis*. 2009;57(2):184–197. Available from: <https://dx.doi.org/10.1080/00207140802665450>. doi:10.1080/00207140802665450.
19. Amores J, Maes P. Essence: Olfactory interfaces for unconscious influence of mood and cognitive performance. *ACM SIGCHI*. 2017;p. 28–34.
20. Tomasi D. *Critical Neuroscience and Philosophy. A Scientific Re-examination of the Mind-body Problem*. Basingstoke, UK: Palgrave Macmillan; 2020.
21. Munyan BG, Neer SM, Beidel DC, Jentsch F. Olfactory Stimuli Increase Presence in Virtual Environments. *PLOS ONE*. 2016;11(6):e0157568–e0157568. Available from: <https://dx.doi.org/10.1371/journal.pone.0157568>. doi:10.1371/journal.pone.0157568.
22. Rochet M, El-Hage W, Richa S, Kazour F, Atanasova B. Depression, Olfaction, and Quality of Life: A Mutual Relationship. *Brain Sciences*. 2018;8(5):80–80. Available from: <https://dx.doi.org/10.3390/brainsci8050080>. doi:10.3390/brainsci8050080.
23. Mitchell AS. The mediodorsal thalamus as a higher order thalamic relay nucleus important for learning and decision-making. *Neurosci Biobehav Rev*. 2015;54:76–88.
24. Courtiol E, Wilson DA. The olfactory thalamus: unanswered questions about the role of the mediodorsal thalamic nucleus in olfaction. *Frontiers in Neural Circuits*. 2015;9. Available from: <https://dx.doi.org/10.3389/fncir.2015.00049>. doi:10.3389/fncir.2015.00049.
25. Jacobson A, Green E, Haase L, Szajer J, Murphy C. Differential Effects of BMI on Brain Response to Odor in Olfactory, Reward and Memory Regions: Evidence from fMRI. *Nutrients*. 2019;11(4):926–926. Available from: <https://dx.doi.org/10.3390/nu11040926>. doi:10.3390/nu11040926.
26. The Inpatient Psychiatry Unit at UVM Medical Center, retrieved on 1/28/2021 at: <https://www.uvmhealth.org/medcenter/departments-and-programs/inpatient-psychiatry>
27. The University of Vermont Medical Center (UVMHC) Shepardson 3, department of inpatient psychiatry, retrieved on 1/28/2021 at: <https://www.uvmhealth.org/medcenter/location/inpatient-psychiatry-shepardson-3>
28. Meng SL, Tak EW, Li W, & L C. The Longitudinal Associations between Physical Health and Mental Health among Older Adults. *Aging & Mental Health*. 1990;24:12–12.
29. Carrigan N, Dysch, Salkovskis. A Replication and Treatment Case Series’, *Behavioural and Cognitive Psychotherapy. The Impact of Health Anxiety in Multiple Sclerosis: A Replication*. 2018;46(2):148–167. doi:<https://doi.org/10.1017/S135246581700056X>.
30. Lupien SJ, McEwen BS, Gunnar MR, Heim C. Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience*. 2009;10(6):434–445. Available from: <https://dx.doi.org/10.1038/nrn2639>. doi:10.1038/nrn2639.

31. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, et al. Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, To-bacco and Alcohol Use in Australian Adults. *International Journal of Environmental Re-search and Public Health*. 2020;17(11):4065–4065. Available from: <https://dx.doi.org/10.3390/ijerph17114065>. doi:10.3390/ijerph17114065.
32. Kamath V, Paksarian D, Cui L, Moberg PJ, Turetsky BI, Merikangas KR. Olfactory processing in bipolar disorder, major depression, and anxiety. *Bipolar Disorders*. 2018;20(6):547–555. Available from: <https://dx.doi.org/10.1111/bdi.12625>. doi:10.1111/bdi.12625.
33. Kohli P, Soler ZM, Nguyen SA, Muus JS, Schlosser RJ. The Association Between Olfaction and Depression: A Systematic Review. *Chemical Senses*. 2016;41(6):479–486. Available from: <https://dx.doi.org/10.1093/chemse/bjw061>. doi:10.1093/chemse/bjw061.
34. Croy I, Hummel T. Olfaction as a marker for depression. *Journal of Neurology*. 2017;264(4):631–638. Available from: <https://dx.doi.org/10.1007/s00415-016-8227-8>. doi:10.1007/s00415-016-8227-8.
35. Eisenberg DM, Kaptchuk TJ, Post DE, Hrbek AL, O’connor BB, Osypiuk K, et al. Establishing an Integrative Medicine Program Within an Academic Health Center: Essential Considerations. *Academic medicine : journal of the Association of. American Medical Colleges*. 2016;91(9):1223–1230.
36. Gartlehner G, Gaynes BN, Amick HR, Asher GN, Morgan LC, Coker-Schwimmer E. Comparative benefits and harms of antidepressant, psychological, complementary, and exercise treatments for major depression: an evidence report for a clinical practice guideline from the American College of Physicians. *Ann Intern Med*. 2016.doi:10.7326/M15-1813
37. Tomasi D. *Mind-Body Medicine in Inpatient Psychiatry*. New York, NY: Ibidem Verlag / Columbia University Press. 2019.
38. Bastos AG, Guimarães LSP, Trentini CM. Neurocognitive changes in depressed patients in psychodynamic psychotherapy, therapy with fluoxetine and combination therapy. *Journal of Affective Disorders*. 2013;151(3):1066–1075. Available from: <https://dx.doi.org/10.1016/j.jad.2013.08.036>. doi:10.1016/j.jad.2013.08.036.
39. Hohmann L, Bradt J, Stegemann T, Koelsch S. Effects of music therapy and music-based interventions in the treatment of substance use disorders: A systematic review. *PLOS ONE*. 2017;12(11):e0187363–e0187363. Available from: <https://dx.doi.org/10.1371/journal.pone.0187363>. doi:10.1371/journal.pone.0187363.
40. Wang J, Hodes GE, Zhang H. Epigenetic modulation of inflammation and synaptic plasticity promotes resilience against stress in mice. *Nature Communications*. 2018;9(1):477–477.
41. Mitchell KS, Am D, Dimartino DM. A pilot study of a randomized controlled trial of yoga as an intervention for PTSD symptoms in women. *J Trauma Stress*. 2014;27(2):121–129.
42. Motraghi TE, Seim RW, Meyer EC, Morissette SB. Virtual Reality Exposure Therapy for the Treatment of Posttraumatic Stress Disorder: A Methodological Review Using CONSORT Guidelines. *Journal of Clinical Psychology*. 2014;70(3):197–208. Available from: <https://dx.doi.org/10.1002/jclp.22051>. doi:10.1002/jclp.22051.
43. Regev D, Cohen-Yatziv L. Effectiveness of Art Therapy With Adult Clients in 2018—What Progress Has Been Made? *Frontiers in Psychology*. 2018;9. Available from: <https://dx.doi.org/10.3389/fpsyg.2018.01531>. doi:10.3389/fpsyg.2018.01531.

How to cite this article: David Tomasi, Hannah Ferris, Priscilla Booraem, Lindsay Enman, Sheri Gates, Emily Reyns. **Olfactory Virtual Reality (OVR) for Wellbeing and Reduction of Stress, Anxiety and Pain.** *Journal of Medical Research and Health Sciences*. 2021;1211–1222. <https://doi.org/10.15520/jmrhs.v4i3.322>