

Master Thesis



F3

Faculty of Electrical Engineering
Department of Computer Graphics and Interaction

SIMR

**Simulating the phenomena of altered
states of consciousness using virtual
reality**

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Fakulta elektrotechnická
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SIMR

**Simulace fenoménů pozměněných stavů
vědomí pomocí virtuální reality**

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Abstract

TODO

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– Jakub Hlusička

Contents

1	Introduction	1
1.1	Problem Statement	2
1.2	Motivation	2
1.2.1	Art and Media	2
1.2.2	Education	2
1.2.3	Research and Psychotherapy	2
1.2.4	Understanding of the Human Mind	3
1.3	Related Work	3
1.3.1	Recreations of Visual Phenomena	3
1.3.2	Tactile Stimulation Interfaces	5
1.4	Contributions	5
2	Background	6
2.1	Altered States of Consciousness	7
2.1.1	Definition	7
2.1.2	Aspects	7
2.2	Replications	7
2.2.1	Replications suitable for Virtual Reality	7
2.3	Psychometric Evaluation Methods	7
3	Implementation	8
3.1	Design of the Application	9
3.1.1	Safety	9
3.1.2	Virtual Scene Creation	9
3.1.3	Experiment Automation	9
3.2	Implementation of Replications	9
3.2.1	Spatial Effects	9
3.2.2	Non-Spatial Effects	9
3.3	Complex Replication	9
3.3.1	Execution Order	9
3.3.2	Biosensor Influence on Replication Parameters	9
4	Evaluation	10
4.1	Methodology	11
4.2	Analysis	11

5	Conclusion	12
5.1	Discussion	13
5.2	Notable Issues Encountered During Development	13
5.3	Limitations	13
5.4	Future Work	13
	Bibliography	14

1 | Introduction

Contents

1.1	Problem Statement	2
1.2	Motivation	2
1.2.1	Art and Media	2
1.2.2	Education	2
1.2.3	Research and Psychotherapy	2
1.2.4	Understanding of the Human Mind	3
1.3	Related Work	3
1.3.1	Recreations of Visual Phenomena	3
1.3.2	Tactile Stimulation Interfaces	5
1.4	Contributions	5

1.1 Problem Statement

This thesis is focused on the development of a virtual reality (VR) application that simulates select aspects of altered states of consciousness (ASCs; further defined in 2.1.1) typically induced by classical psychedelics such as LSD and psilocybin/psilocin. We focus primarily on the recreation of the ASCs' effects on sensory perception using an analytical approach.

1.2 Motivation

Due to their high degree of immersion, VR systems, with head-mounted displays (HMDs) in particular, offer a unique opportunity for recreating certain aspects of ASCs.

1.2.1 Art and Media

ASCs of various forms have had a significant influence on art for millenia. Earliest signs of inductions of ASCs via neurotropic substances have been found possibly as early as 60,000 BC (Guerra-Doce 2015). ASCs continue to be depicted in or influence contemporary popular media.

An analysis and a recreation of certain aspects of ASCs may serve as a reference point for recreating those aspects of ASCs in popular media.

1.2.2 Education

While experiencing a simulation of an ASC is unlikely to be fully representative of the ASC the simulation is modelled after, we propose that the simulation may be significantly less inductive of difficult experiences colloquially known as "bad trips".

This may be a viable alternative form of experiencing certain aspects of ASCs, while the possession or consumption of mind-altering substances is illegal in most countries. The resulting VR application may serve as an educational tool about ASCs which would not require as controlled of an environment as is required in psychedelic-assisted psychotherapy.

1.2.3 Research and Psychotherapy

Aday, Davoli, and Bloesch (2020) make an interesting observation, that psychedelics and VR are utilized in tandem to enhance the experience of recreational users. Moreover, the authors claim that VR could also be used to optimize and tailor the therapeutic setting during psychedelic sessions.

Most importantly, however, the authors state, that:

[...] VR may be a useful tool for preparing hallucinogen-naïve participants in clinical trials for the sensory distortions experienced in psychedelic states.

Nonetheless, as mentioned previously, care should be taken to ensure that users experiencing the simulation are informed about the simulation not being fully representative of the **ASC** it is modelled after. While a **VR** simulation may be suitable for simulating sensory effects of **ASCs**, other effects, such as the effects on cognition, may be much more difficult, if not impossible, to directly replicate via **VR** technologies alone. If uninformed, users may gain a false impression about the **ASC**.

1.2.4 Understanding of the Human Mind

Finally, without any immediate application, the study of the effects of **ASCs** may help contribute to our understanding of the human mind. Particularly, for instance, analyzing the invariant effects of classical psychedelics on sensory perception may improve our understanding of the visual cortex and the way it functions. Further research involving perceptual phenomena and pharmacodynamics of psychedelics and their mechanisms of action may contribute to our understanding of the significance of certain receptors in processing visual or other sensory information.

1.3 Related Work

1.3.1 Recreations of Visual Phenomena

In this section, we explore the way **ASCs** have been depicted in contemporary art and media and recent attempts at recreating aspects of **ASCs** in the scientific domain.

1.3.1.1 Quake Delirium

In the original paper about Quake Delirium (Weinel 2011), the author divides video games portraying **ASCs** into two categories:

1. Games which feature literally portrayed dreams, intoxication or hallucinogenic experiences.
2. Games which feature graphical or thematic content which audiences may consider to reflect states of dream, intoxication or hallucination, but without any direct or literal reference to these states.

This categorization is not only useful for examining video games, but also the rest of art and media.

The first category describes media that attempts to recreate **ASCs** with an explicit reference to a specific induction method, cause or origin. For example, the games

in this category, such as *Grand Theft Auto: Vice City*¹ or *Duke Nukem 3D*², may temporarily portray a character under the influence of a psychoactive drug. However, psychoactive substances are not the only form of *ASC* induction portrayed in video games. One such exception is *LSD: Dream Emulator*³, a game with narrative based on a dream diary and an overall dream-like surrealist aesthetic.

The second category contains media that does not communicate explicitly any *ASC* method of induction, cause or origin. Despite this, the media that falls into this category may be viewed equally as *psychedelic* or more than that of the first category. This could be considered to be the case of *Yoshi's Island*⁴. While the creators may not have intended the video game to reflect *ASCs*, because of its brightly colored surrealistic visual themes, it may resemble *ASCs* of games from the first category.

The *Quake Delirium* project itself is a modification of the game *Quake* that makes use of an external digital signal processing (*DSP*) audio patch for modifying the resulting audiovisual output the game produces. The visual effects consist of changes in:

1. field of view (*FOV*);
2. camera swaying;
3. fog density and color;
4. game speed;
5. stereo vision (for 3D red cyan glasses);
6. gamma;
7. hue.

These visual effects are made available to the *DSP* patch, the control of which can be automated using multi-track audio sequencing software. This enables the effects to onset slowly and gradually become more severe over time.

The project demonstrates a method of combining multiple partial effects that results in a complex audio-visual effect that is more sophisticated than many of the existing games exhibiting phenomena of *ASCs* surveyed.

1.3.1.2 Crystal Vibes

(Outram et al. 2017) tactile stimulation further discussed in 1.3.2

1.3.1.3 Isness

(Glowacki et al. 2020)

¹Grand Theft Auto: Vice City, Rockstar Games, 2003. PC (Windows) CD-ROM.

²Duke Nukem 3D, 3D Realms, 1996. PC (Windows) CD-ROM.

³LSD: Dream Emulator, Asmik Ace Entertainment, 1998. Playstation.

⁴Super Mario World 2: Yoshi's Island, Nintendo, 1995. Super NES.

1.3.1.4 Hallucination Machine

(Suzuki et al. 2018)

1.3.2 Tactile Stimulation Interfaces

1.3.2.1 Synesthesia suit for Rez Infinite

(Konishi, Hanamitsu, Outram, Minamizawa, et al. (2016), Konishi, Hanamitsu, Outram, Kamiyama, et al. (2016) and Synesthesia Lab (2016)) further improved by (Furukawa et al. 2019)

1.3.2.2 Synesthesia X1 - 2.44

(Synesthesia Lab 2021)

1.3.2.3 Subpac

(SUBPAC (2013), Drempetic and Potter (2017)) used in (Zimmermann, Helzlsouer, and Arellano 2016) and studied on deaf people (Schmitz, Holloway, and Cho 2020)

1.4 Contributions

We develop a VR application for HMDs that simulates select aspects of ASCs. We perform a study in which we measure the influence of the created VR application on the human mind. This measurement is done via the 11-factor altered states of consciousness questionnaire (11-ASC; Studerus, Gamma, and Vollenweider (2010)), that is used in clinical studies of psychedelic drugs.

2 | Background

Contents

2.1	Altered States of Consciousness	7
2.1.1	Definition	7
2.1.2	Aspects	7
2.2	Replications	7
2.2.1	Replications suitable for Virtual Reality	7
2.3	Psychometric Evaluation Methods	7

2.1 Altered States of Consciousness

2.1.1 Definition

2.1.2 Aspects

2.2 Replications

2.2.1 Replications suitable for Virtual Reality

2.3 Psychometric Evaluation Methods

3 | Implementation

Contents

3.1	Design of the Application	9
3.1.1	Safety	9
3.1.2	Virtual Scene Creation	9
3.1.3	Experiment Automation	9
3.2	Implementation of Replications	9
3.2.1	Spatial Effects	9
3.2.2	Non-Spatial Effects	9
3.3	Complex Replication	9
3.3.1	Execution Order	9
3.3.2	Biosensor Influence on Replication Parameters	9

3.1 Design of the Application

3.1.1 Safety

3.1.2 Virtual Scene Creation

3.1.3 Experiment Automation

3.2 Implementation of Replications

3.2.1 Spatial Effects

3.2.1.1 Depth Perception Distortion

3.2.1.2 Waviness or "Breathing" of Objects

3.2.2 Non-Spatial Effects

3.2.2.1 Visual Acuity Enhancement

3.2.2.2 Hue Shifting

3.2.2.3 Tracers

3.3 Complex Replication

3.3.1 Execution Order

3.3.2 Biosensor Influence on Replication Parameters

4 | Evaluation

Contents

4.1	Methodology	11
4.2	Analysis	11

4.1 Methodology

4.2 Analysis

5 | Conclusion

Contents

5.1	Discussion	13
5.2	Notable Issues Encountered During Development	13
5.3	Limitations	13
5.4	Future Work	13

5.1 Discussion

5.2 Notable Issues Encountered During Development

5.3 Limitations

5.4 Future Work

List of Acronyms

11-ASC 11-factor altered states of consciousness questionnaire

ASC altered state of consciousness

DSP digital signal processing

FOV field of view

HMD head-mounted display

VR virtual reality

Bibliography

- Aday, Jacob S, Christopher C Davoli, and Emily K Bloesch. 2020. "Psychedelics and virtual reality: parallels and applications." *Therapeutic Advances in Psychopharmacology* 10:2045125320948356.
- Drempetic, Cassandra, and Leigh Ellen Potter. 2017. "Wearable bass tactile sound systems and immersion." In *Proceedings of the 29th Australian Conference on Computer-Human Interaction*, 576–580.
- Furukawa, Taichi, Nobuhisa Hanamitsu, Yoichi Kamiyama, Hideaki Nii, Charalampos Krekoulotis, Kouta Minamizawa, Akihito Noda, Junko Yamada, Keiichi Kitamura, Daisuke Niwa, et al. 2019. "Synesthesia Wear: Full-body haptic clothing interface based on two-dimensional signal transmission." In *SIGGRAPH Asia 2019 Emerging Technologies*, 48–50.
- Glowacki, David R, Mark D Wonnacott, Rachel Freire, Becca R Glowacki, Ella M Gale, James E Pike, Tiu de Haan, Mike Chatziapostolou, and Oussama Metatla. 2020. "Isness: using multi-person VR to design peak mystical type experiences comparable to psychedelics." In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–14.
- Guerra-Doce, Elisa. 2015. "Psychoactive substances in prehistoric times: examining the archaeological evidence." *Time and Mind* 8 (1): 91–112.
- Konishi, Yukari, Nobuhisa Hanamitsu, Benjamin Outram, Youichi Kamiyama, Kouta Minamizawa, Ayahiko Sato, and Tetsuya Mizuguchi. 2016. "Synesthesia suit." In *International AsiaHaptics conference*, 499–503. Springer.
- Konishi, Yukari, Nobuhisa Hanamitsu, Benjamin Outram, Kouta Minamizawa, Tetsuya Mizuguchi, and Ayahiko Sato. 2016. "Synesthesia suit: the full body immersive experience." In *ACM SIGGRAPH 2016 VR Village*, 1–1.
- Outram, Benjamin, Yukari Konishi, Aria Shimbo, Reiko Shimizu, Kouta Minamizawa, Ayahiko Sato, and Tetsuya Mizuguchi. 2017. "Crystal Vibes feat. Ott: A psychedelic musical virtual reality experience utilising the full-body vibrotactile haptic synesthesia suit." In *2017 23rd International Conference on Virtual System & Multimedia (VSMM)*, 1–4. IEEE.
- Schmitz, Anastasia, Catherine Holloway, and Youngjun Cho. 2020. "Hearing through Vibrations: Perception of Musical Emotions by Profoundly Deaf People." *arXiv preprint arXiv:2012.13265*.

- Studerus, Erich, Alex Gamma, and Franz X Vollenweider. 2010. "Psychometric evaluation of the altered states of consciousness rating scale (OAV)." *PloS one* 5 (8): e12412.
- SUBPAC. 2013. "The SUBPAC front page." Accessed February 27, 2022. <https://web.archive.org/web/20220227213936/https://subpac.com/>.
- Suzuki, Keisuke, Warrick Roseboom, David J Schwartzman, and Anil K Seth. 2018. "Hallucination Machine: Simulating Altered Perceptual Phenomenology with a Deep-Dream Virtual Reality platform." In *ALIFE 2018: The 2018 Conference on Artificial Life*, 111–112. MIT Press.
- Synesthesia Lab. 2016. "The Synesthesia Suit product page." Accessed February 27, 2022. <https://web.archive.org/web/20220227212257/https://synesthesia-suit.com/>.
- Synesthesia Lab. 2021. "The Synesthesia X1 - 2.44 product page." Accessed February 27, 2022. <https://web.archive.org/web/20220227211421/https://synesthesialab.com/x/>.
- Weinel, Jonathan. 2011. "Quake delirium: remixing psychedelic video games." *Sonic Ideas/Ideas Sonicas* 3 (2).
- Zimmermann, Marc, Volker Helzle, and Diana Arellano. 2016. "Longing for wilderness." In *ACM SIGGRAPH 2016 VR Village*, 1–2.