CIFAR
IDEAS EXCHANGE

RESEARCH SUMMARY

A SERIES OF SUMMARIES OF INFLUENTIAL RESEARCH STUDIES CONDUCTED BY CIFAR PROGRAM MEMBERS

AZRIELI PROGRAM IN BRAIN, MIND & CONSCIOUSNESS

OPENING THE (VIRTUAL) DOORS OF PERCEPTION

Simulated hallucinations in virtual reality produce a similar visual experience to psychedelic drugs, shedding light on the processes that underlie visual perception in the brain.

KEYWORDS

Hallucination, deep learning, machine, consciousness, virtual reality

FOCUS OF STUDY

This study combined virtual reality and machine learning in a hallucination simulator to investigate how the brain processes the conscious perception of visual information. The researchers compared participants' reported experiences of the hallucination simulator, a control video, and the hallucinogenic drug psilocybin.

BACKGROUND

Hallucinogenic drugs and psychiatric conditions have long generated interest in the workings of altered states of consciousness. These drugs — such as LSD and psilocybin (mushrooms) — as well as conditions like psychosis have long been used to study these altered states.

Resurging interest in this area has led to new research on the effects on conscious experience of hallucinatory imagery as experienced through virtual reality (VR). Simulating hallucinogenic experiences in VR allows researchers to study the mechanisms behind the perception of hallucinations without the interference of other physiological and cognitive effects caused by drugs or psychiatric conditions.

A new study by **Anil Seth**, Senior Fellow of the **Azrieli program in Brain, Mind & Consciousness at CIFAR**, and colleagues at the University of Sussex aims to produce more accurate hallucination simulations than those used in previous VR research. To do this, the research team, including primary author Keisuke Suzuki, used recorded real-world visual environments rather than less realistic computer-generated imagery. They argue this provides a closer approximation to real visual hallucinations, allowing for better investigation of the visual aspects of altered states of consciousness.

STUDY DESIGN AND METHODS

To simulate hallucinatory experiences for study participants, the researchers created the Hallucination Machine, a VR headset with a 360-degree panoramic display. The Hallucination Machine uses two technologies: deep convolutional neural networks (DCNNs) and panoramic videos of natural (i.e. real) scenes. DCNNs are machine learning systems that mimic processing in the brains of humans and other primates. Often they're used to enable machine vision, as they are able to recognize objects in images.

To add a hallucinogenic quality to the panoramic videos, the researchers modified a novel visualization algorithm called Deep Dream, which identifies categorical features the deep convolutional neural network has learned — faces, for example. Deep Dream transforms the everyday surroundings depicted in the VR videos by adding hallucinatory interpretations of the landscape, such as integrating dog faces into objects.

The researchers compared the simulated hallucinations to real ones through two experiments. The first experiment tested how well the Hallucination Machine mimicked real hallucinations. Starting with 12 participants, the researchers compared participant experiences while wearing the Hallucination Machine to their experiences viewing an unaltered control video and to reports of psychedelic states experienced through use of the hallucinogenic drug psilocybin.

The second experiment investigated whether using the technology induced temporal distortion — a commonly reported aspect of altered consciousness that warps the perception of time. To test this, researchers gave participants a time-keeping task while they experienced the Hallucination Machine or watched control videos. Afterward, participants also rated their subjective experiences of time during the simulated hallucinatory experience or control.

KEY FINDINGS

Study participants reported perceptual experiences from the Hallucination Machine that were similar to the experiences reported in previous studies by individuals under the influence of psilocybin. Participants rated similar perceptual experiences across several measures of subjective experience, including the strangeness, patterns and colours of the imagery, the intensity of the experience, and a distorted sense of size and space.

There were no such similarities between ratings of the Hallucination Machine and control experiences.

However, the second experiment revealed that participants did not perceive time differently when experiencing the simulated hallucinations compared to the control videos.

FIGURES

Middle Layer (inception _3b/output)

Higher Layer (inception_4d/pool)

Deep-Dreamed Images

CONCLUSION AND IMPLICATIONS

The machine-generated hallucinations gave participants a qualitatively similar experience to a pharmacologically-induced hallucinatory experience, but did not give them an altered perception of time.

This study provides a basis for understanding the visual aspect of altered states of consciousness that may be used in the field of psychiatry and the study of consciousness. In particular, the study sheds light on how visual hallucinations are processed in the brain. DCNN and Deep Dream technologies process information in a similar way to the human visual system, so they may provide a new way of investigating the neural mechanisms

of visual perception. The Deep Dream algorithm processes visual information modeled after predictive processing theories of perception. In this algorithm, visual perceptions are achieved by multiple layers of processing that produce a perceived image by balancing what people expect to see with the sensory signals they receive. The researchers suggest that hallucinations may occur when either of these two inputs is thrown out of balance, for instance by drugs or perceptual impairments.

This research demonstrates that the complexity of hallucinations appears to be controlled by the level of processing in the neural network at which these inputs are altered. Manipulating lower layers resulted in simpler, geometric imagery, while altering higher layers resulted in hallucinations of faces, objects and scenes. The researchers propose that the human visual system may work in a similar way.

The failure of the simulated hallucinatory experience to induce altered perception of time in this experiment suggests that warped time experiences may depend on effects of psychedelic compounds that aren't directly related to visual perception.

REFERENCES

A Deep-Dream virtual reality platform for studying altered perceptual phenomenology. Anil K. Seth et al., Scientific Reports; 2017;7:issue 15982.

RESEARCH BRIEF AUTHORSHIP

Stephanie Orford, BSc (Honours) Behavioural Neuroscience, Simon Fraser University, for CIFAR.

AZRIELI PROGRAM IN BRAIN, MIND & CONSCIOUSNESS AT CIFAR

Where does human consciousness come from, and why is it important? The quality of our consciousness is what sets us apart from other species, and seems to be one of the defining traits of being human. Yet the nature of consciousness remains a mystery. This CIFAR program grapples with the fundamental underpinnings of consciousness and the deep implications for health, technology, and society.

CIFAR

MaRS Centre, West Tower
661 University Ave. Suite 505
Toronto, ON M5G 1M1

www.cifar.ca