HyperDrum: Interactive Synchronous Drumming in Virtual Reality using Everyday Objects

Ryo Hajika
ryo.hajika@auckland.ac.nz
ECL, The University of Auckland
Auckland, New Zealand

Kunal Gupta
kgup421@aucklanduni.ac.nz
ECL, The University of Auckland
Auckland, New Zealand

Prasanth Sasikumar
prasanth.sasikumar.psk@gmail.com
ECL, The University of Auckland
Auckland, New Zealand

Yun Suen Pai
yspai1412@gmail.com
ECL, The University of Auckland
Auckland, New Zealand

Figure 1: (left) two participants engaged in HyperDrum, and (right) interactive virtual environment for hyperscanning

ABSTRACT

Hyperscanning is a method to detect if brain wave synchronicity exists between two or more individuals, which is usually due to behavioral or social interactions. It is usually limited to neuroscience studies and very rarely used as an interaction or visual feedback mechanic. In this work, we propose HyperDrum, which is about leveraging this cognitive synchronization to create a collaborative music production experience with immersive visualization in virtual reality. We let the participants wear electroencephalography (EEG) head-mounted displays to create music together using a physical drum. As the melody becomes in synced, we perform hyperscanning to evaluate the degree of synchronicity. The produced music and visualization reflects the synchronicity level while at the same time trains the participants to create music together, enriching the experience and performance. HyperDrum's main goal is twofold; to blend cognitive neuroscience with creativity in VR, and to encourage connectivity between humans using both art and science.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative content creation**.

KEYWORDS

hyperscanning, electroencephalography, virtual reality, music

ACM Reference Format:
Ryo Hajika, Kunal Gupta, Prasanth Sasikumar, and Yun Suen Pai. 2019. HyperDrum: Interactive Synchronous Drumming in Virtual Reality using Everyday Objects. In *SIGGRAPH Asia 2019 XR (SA '19 XR), November 17–20, 2019, Brisbane, QLD, Australia.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3355355.3361894

SA '19 XR, November 17–20, 2019, Brisbane, QLD, Australia

ACM ISBN 978-1-4503-6947-3/19/11…$15.00
https://doi.org/10.1145/3355355.3361894

1 INTRODUCTION

Synchronized movements can be observed in activities like dancing, yoga, and so on, where the performance level is governed by the experience of the user. New users would most definitely take longer to learn specific movements, whereas experienced users who have undergone intensive training are usually in sync with the crowd's movements. If we measure the brain signals of two individuals performing the same action at the same time while facing each other, we find that the alpha waves (8 - 13Hz) peak at the same time with very low deviation between them. This is the core concept behind hyperscanning, which is the possibility of synchronized brain waves when two or more participants are measured at the same time. This leads us to believe that sycnhronicity in the brain waves could potential allow us to learn and perform better for collaborative activities.

Leveraging this, we propose HyperDrum, which is a creative, collaborative music production tool in virtual reality. When the participants' brain signals are synchronized, the quality of the music increase and so does the visualization to create an interactive piece in virtual reality that is an amalgamation of each participant's unique style and sense of creativity.

2 RELATED WORK

The concept of simultaneous brain wave measurement was first envisioned by Duane et al. [Duane and Behrendt 1965] who wished to understand extrasensory communication between twins. However, hyperscanning was only coined by Montague et al. [Montague et al. 2002] who performed simultaneous functional magnetic resonance imaging (fMRI) scan on two participants playing an interaction game. In this approach, in can be said that the game actually induces brain syncronicity, thus effecting the performance of the individuals playing the game.

A very recent paper in fact demonstrated hyperscanning when two professional violinist performed together [Vanzella et al. 2019]. It was found that the region of the brain activates similarly between the two violinists, suggesting that they were in synced with each other. In HyperDrum, we wish to use a virtual music creation tool to induce synchronicity, then provide continuous audio and visual stimulus to increase the quality and performance of the music production, as well as improve the experience for the participants to let them experience a music piece that can only be achieved with hyperscanning.

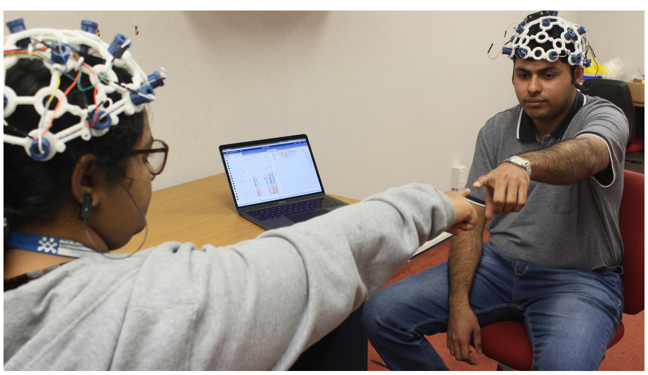

Figure 2: Hyperscanning using OpenBCI EEG headset

3 IMPLEMENTATION

Hyperscanning in virtual reality is achieved using a pair of EEG sensors. For our demo, we use two LooxidVR head mounted displays which comes equipped with a 6-channel EEG sensor that samples at 1000Hz. For synchronicity to be achieved, a pair of individuals need to share the same motion or interaction after a period of time, such as a simple finger-moving task [Yun et al. 2012]. Based on this, our drumming task is used for this particular task, while also enriching the experience of music creation and bridging the gap between art and science.

Firstly, we arrange everyday objects, such as bowls and chopsticks to be used as musical instruments (3 bowls per person, representing 3 drums). We trained a model to recognize the sound source when hitting each of these bowls with a piece of chopstick (used for the drum stick). The sound source used is the Mel-Scale Log Spectrum (MSLS), which is the log power spectrum at the Mel-Frequency Domain given a time window of 1 second [Kumon et al. 2007]. We used the support vector machine (SVM) classifier to then train the model. For the EEG signals, we calculate the band power of the alpha channel (frequency range from 8-12Hz) taken from the prefrontal cortex, which best reflects the emotional expression and sense of creativity, of the participants and compare them. After preprocessing the signal, we then calculate the Phase Locking Value (PLV) from both participants to compute the synchronicity rate. Both the output of the sound classifier and the computed synchronicity rate are them piped to the virtual environment which is built using Unity. The virtual environment is shared among both participants and requires an internet connection.

4 EXPERIENCE

Both the participants are seated in front of a table with everyday objects placed on them. We pre-train the model to recognize the sound sources from these objects. Then, each of the participant puts on the HMD and holds a VR controller strapped to another normal object representing the drum stick. As the participants begin playing the music, the initial audio output is underwhelming, as visual guide is used to improve the performance to be in synced with each other. As the participants slowly learn and get used to it, their brain waves will also gradually synchronize due to audio, visual and motion cues. Eventually, the resulting music piece improves with audio visualization used to reflect their performance. The entire demonstration will take no longer than 5 minutes with two simultaneous participants each time. For the demonstration, we will improve on the visualization and music quality to deliver a more immersive experience.

ACKNOWLEDGMENTS

This project is supported by the NZ TEC Entrepreneurial Fund.

REFERENCES

Thomas D Duane and Thomas Behrendt. 1965. Extrasensory electroencephalographic induction between identical twins. *Science* 150, 3694 (1965), 367.

Makoto Kumon, ITO Yoshihiro, Toru Nakashima, Tomoko Shimoda, and Mitsuaki Ishitobi. 2007. Sound source classification using support vector machine. *IFAC Proceedings Volumes* 40, 13 (2007), 465–470.

P Read Montague, Gregory S Berns, Jonathan D Cohen, Samuel M McClure, Giuseppe Pagnoni, Mukesh Dhamala, Michael C Wiest, Igor Karpov, Richard D King, Nathan Apple, et al. 2002. Hyperscanning: simultaneous fMRI during linked social interactions.

Patricia Vanzella, Joana Bisol Balardin, Rogério Akira Furucho, Guilherme Augusto Zimeo Morais, Thenille Braun Janzen, Daniela Sammler, and Joao Ricardo Sato. 2019. fNIRS Responses in Professional Violinists While Playing Duets: Evidence for Distinct Leader and Follower Roles at the Brain Level. *Frontiers in psychology* 10 (2019), 164.

Kyongsik Yun, Katsumi Watanabe, and Shinsuke Shimojo. 2012. Interpersonal body and neural synchronization as a marker of implicit social interaction. *Scientific reports* 2 (2012), 959.