Visum: visual evoked potential as sonic sculpture

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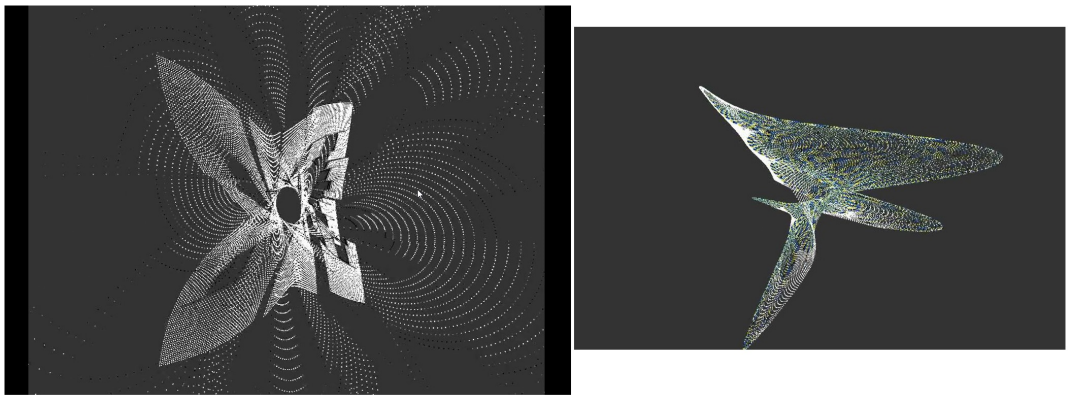

Figure 1: Visualizations of VEP data

ABSTRACT

In this research, Visum, an immersive audio/visual application, which uses visual perception through an interface to create sound and visual objects is presented. Visual evoked potentials (VEP) are changes in brainwave electrical activity that are created when a visual stimulus is presented to an observer. Here, VEPs are generated through observing optical illusions. These VEPs are brought into an environment as three-dimensional sound and visual objects. The VEP objects can be played as an instrument via a user-controlled interface such as mixing and parameter control creating an evolving, dynamic, sounds and visuals. Visum is created for artistic and educational purposes.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods; • **Applied computing** → Arts and humanities; Media arts.

KEYWORDS

Visual perception, sonification, visualization, optical illusion, visual evoked potential, HCI, EEG

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1 INTRODUCTION

Electroencephalogram (EEG) is a non-invasive method for recording electrical brain activity [Lutters and Koehler, 2016] using scalp electrodes, first discovered by Hans Berger in 1929. A Visual Evoked Potential (VEP) can often be seen in the background EEG recorded from the occipital scalp following a flash of light [Creel, 2012]. Visual perception refers to the interpretation of what we take in through our eyes. Optical illusions give us insight into how the brain works. They use patterns, light and color that create images, which can be deceptive to our brains and such reveal the mechanisms of perception [Bach and Poloschek, 2006]. Optical illusions occur, because our brain is trying to interpret what we see and make sense of the world around us.

In this research, a subject's VEP data is retrieved, which includes the various latencies that take place post-stimulus. Latency refers to a delayed potential response within a certain time interval after a stimulus is presented. The VEP data is used as objects in an immersive audio/visual space. In [Mathew et al., 2017], a 3D sound installation was created where, a multivariate event-based sonification was proposed using 3D spatial location to provide cues about these particular events occurring in the brain. This research also creates a 3D sound environment. Here, illusion based VEP features (e.g. peaks/spectral density) are used to provide sound cues. These cues represent the different areas of the brain and what happens when someone observes a visual stimulus. Emphasis is placed on the experience of creating soundscapes from visual perception. Thus, Visum, a 3D audio/visual immersive environment based on VEP evoked by optical illusions is presented.

2 METHODOLOGY

The OpenBCI UltraMark IV EEG device [OpenBCI 2020] for EEG data collection and Max/MSP/Jitter [Cycling '74 2020] for sonification and visualization are used in this experiment. Here eight channels of data are used representing the eight sensors used to retrieve brainwave data of each participant. Participants were presented with four optical illusions as shown in Figure 2, while their brainwaves were being recorded from the EEG device. Digital filtering, segmentation, trial averaging and analysis are performed on participants' brainwaves to extract the VEP data, which is then used for sonification and visualization (Fig. 3). The VEP data from each participant is considered an object with its own aural and visual representation within this space.

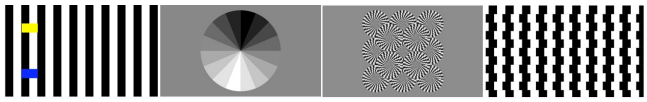

Figure 2: Four illusions used in this research (left to right); Stepping Feet, Reverse Spoke Wheel, Rotating Snakes and Café Wall

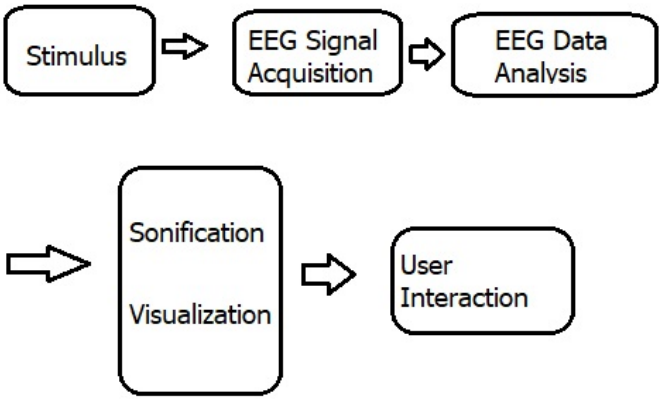

Figure 3: Visum research workflow

3 IMPLEMENTATION

VEPs evoked by optical illusions have not yet been used in Media Arts as a modality. The multimodal design of Visum includes VEP data and user interaction. Sonification of the VEP data involves the use of the granular synthesis method, which is used to break the VEP signal up into small grains and recombined in real-time [Roads, 1988]. These grains are manipulated by the user, for example, grain size or pitch shifting that generate a layered sound for each channel of data. These sound objects are further spatialized and played back using an interface. The VEP sounds are instrumental in creating a textured soundscape. These multi-channel sounds represent the neuronal firings or activity in the brain allowing the user to learn about the visual perception process. The sonic and visual output result is an iterative feedback loop of listening, engaging and manipulating. The multimodal representation from the system output is a function of rhythmic information from the participants VEP data as well as the user interaction of the system.

The purpose of the VEP data visualization is to reflect the changes caused by a certain visual stimulus, i.e. optical illusion. In addition, the visuals are morphed according to the degree of fluctuations in the brainwaves reflecting the perception of the participant. The visualization includes several visual effects such as noise, blurring and shape deformation. The visualization is also synced with the audio spatialization, showing the prominence of each audio channel.

4 CONCLUSION AND FUTURE WORK

This ongoing research seeks to externalize visual evoked potentials, into sonic and visual sculptures. It began from exploring EEG data and wanting to know how people perceive visual information and how this affects their brainwaves to deriving information and knowledge about visual perception. Here the observer of the optical illusions becomes the observed, allowing the audience to learn about the visual perception process. Visum, represents a 3D multimodal immersive space, where VEPs are used as compositional building blocks. Future work and research will include recreating optical illusion art from the VEP data as well as understanding effects of various sonification and visualization mapping strategies on audience perception and application evaluations. The overall goal is to offer pathways within the field of human computer interaction by introducing novel sensory methods of interfacing with computer systems that aim to amplify human qualities.

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