

V F C: An adaptive cinema experience powered by brain-computer interface

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Abstract

V F C is a live cinematographic feature-length experience that takes advantage of mobile electroencephalography (EEG) to provide the filmgoers with a customized soundtrack offered through a novel hybrid sound system approach. The movie takes viewers on an unsettling journey during which they follow a female neuroscientist facing the shadows of her own mind, instantiating a form of reversed *mise en abyme* which gives a role to the spectator's mental states to play in diegetic and extra-diegetic sound elements. It relies on VFC BiomedixTM, a technological platform designed to support a multi-user adaptive media experience by tailoring the movie soundtrack in real-time to one's reactions to the cinematographic content. The platform is composed of a data acquisition system with real-time signal processing capabilities, a modular soundtrack built and operated via live music software, and a dual audio system based on bone-conduction earphones supplementing typical cinema speakers. We hope that this piece fosters innovative strides in adaptive storytelling, paving the way for future explorations in how technology-driven personalization can transform the cinematic experience.

Keywords

adaptive cinema; movie theater; non-linear storytelling; brain-computer interface; biofeedback; electroencephalography (EEG);

Introduction

The intersection of interactive art and technology has gained prominence over recent decades, with advancements enabling dynamic engagement across various artistic domains. Historically, such art forms have predominantly featured in installations, performances, and museums. Landmark creations, like "Music for Solo Performer" (1982) by Alvin Lucier [1] and more recent works such as "Noor" (2016) by Ellen Pearlman [2] and "The Moment" (2018) by Richard Ramchurn [3], demonstrate the potential of using EEG signals to dynamically modify art content. Adaptive content is characterized by non-linear storytelling, as participants can now engage in laid-back experiences with minimal or without any form of interaction at all while audio and/or visual components are being tailored, on an intermittent or

on-going basis, from the real-time analysis of their reactions or emotions through the use of bio-signal devices such as EEG headsets, ECG wristbands and infra-red cameras to name but a few [4]. Integrating adaptivity and generative media content into artistic practices creates opportunities for audience members to actively shape the artwork. This interactivity opens avenues for exploring new narrative forms, linking the viewer's mental state to the evolution of the story's events.

Intention

The leap from generative film-art to full-length adaptive cinema for a more mainstream audience, with a large number of simultaneous viewers, represents a significant evolution in movie experience. By capitalizing on the inherent ambiguity in cinematic scenes, V F C creates soundscapes that lead to varied interpretations of the same scene, leveraging psychological horror tropes to foster a new form of mirror-effect connection with the characters (**Figure 1**). This dynamic audio environment is driven by real-time biosignals, enabling a unique exploration of non-linear narratives that adapt to the viewer's instantaneous mental state. This technology invites a deeper engagement with the film, offering a personalized interpretation and experience for each audience member, thereby transforming traditional cinema into an interactive, adaptive journey.



Figure 1. Picture of a viewer experiencing V F C in a theatre. Equipped with an EEG headset and bone-conduction earphones, the viewers reactions to the movie influences their individualized soundtrack.

V F C, the movie

Synopsis

A neuroscientist develops a rare form of melophobia after suffering from a musical Stendhal syndrome. Witnessing the strange behavioral transformations of her colleagues who were exposed to the same anonymous piece of music, she flees to shelter herself from a world where music has invaded all the sound space.

Experience

The V F C experience begins with an onboarding phase, where participants are guided on how to properly wear the EEG headset and bone-conduction earphones. This preparation is crucial to ensure accurate data collection and an optimal individualized movie experience, hinging on the participant's EEG responses.

During the film, the V F C experience leverages a gating process to craft a non-linear narrative, dynamically shaped by EEG-derived features. This process measures brain signal features during specific time windows to initiate subsequent switching between two audio streams. The gating mechanism is strategically employed 13 times throughout the film, creating an extensive range of auditory experiences. As a result, each viewer is presented with a soundtrack that is not only unique but also intimately aligned with their individual cognitive and emotional reactions to the unfolding story.

The post-screening phase offers an additional interactive element. Participants have the opportunity to engage with a specially designed mobile web app, providing a detailed overview of their individual journey throughout the movie. This summary includes insights into the characters and scenes that engaged them the most, and also offers a comparative analysis of their experience against that of other viewers. This feature not only enhances the understanding of one's own engagement with the film but also fosters a sense of community and shared experience among the audience.

Operational constraints

Addressing the challenge of compatibility and ease of deployment, we developed a system that is both portable and adaptable, ensuring seamless integration with a variety of movie theater setups. The technology is designed for accessibility, prioritizing intuitive use to accommodate a broad range of users without requiring extensive technical knowledge. Additionally, a strong emphasis is placed on data privacy, ensuring that all personal and neurophysiological data collected during the experience are securely handled, anonymized and protected, in accordance with the laws in force regarding the protection of personal data.

VFC Biomedix™

V F C relies on a proprietary, patent-pending adaptive audio system called VFC Biomedix™. This technology generates and broadcasts simultaneous sound streams based on real-time analysis of any kind of biosignals - heartbeat (ECG); brainwave (EEG); ocular movement (EMG) (**Figure 2**). A creative thinking design approach was adopted through multiple iterations and prototypes, with the objective of finding the right balance between optimization, execution, and operability in order to release the experience on the theatrical exhibition market and the immersive XR circuit.

Tests were conducted during a two year period among a pool of close to a hundred testers to gather data and improve the system robustness. Those tests helped us determine modeling parameters with the goal of ensuring maximal variability across viewers, and confirmed that the data of each viewer led to a unique and individualized experience (2 streams raised to power 13 gates equals 8,192 different audio pathways).

The system developed by our team has the potential to help media producers make fully customized experiences for each member of their audiences. On top of using it on future filmgoing experiences, we are looking to implement this next generation of adaptive and augmented audio technologies in multi-user environments for both linear and interactive / XR and immersive entertainment, as well as live and virtual performances.

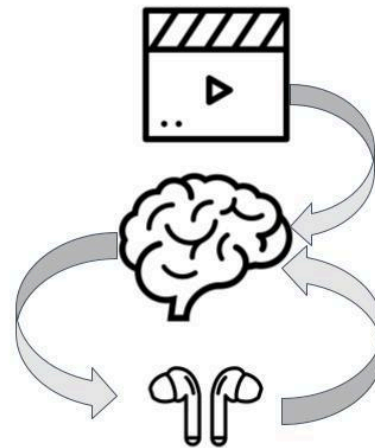


Figure 2. Adaptive hybrid sound system workflow. The movie content influences spectators' brainwaves, which are measured and used in real-time to generate individualized soundtracks. This setups creates a feedback loop that allows creative designs.

Dual sound system

A hybrid audio system was based on a dual layer approach, separating the movie soundtrack into two distinct components : a fixed soundtrack, designed to be played in the screening room speakers for everyone to hear, and an individualized dynamic overlay played in bone-conduction earphones. The fixed soundtrack, as in any movie, acts as a ligand between cinematographic elements. It ensures the spectator's immersion through high-quality audio, strong infra-bass elements, and accurate audiovisual

synchronization. The individualized soundtrack, on the other hand, adapts to the users mental states to enrich their experience with sound effects, musical accompaniments or ambiance textures.

Online processing pipeline

The second core aspect of this technology is its ability to read and interpret biosignals in real-time to produce an individualized experience and convey it to its audience in multi-users settings. The processing pipeline is composed of two key hardware elements: a miniature computer associated with each seat, designed to handle biosignals acquisition and processing, and a centralized server used to generate, synchronize and broadcast the audio streams. Users inputs (biosignals) and outputs (individualized audio stream) are handled by the miniature computer over bluetooth protocol.

Biosignals acquisition

Acquisition of biophysiological data is done on a Latte Panda™ miniature computer modified to run a Python neuroanalytics software built by Re-Ak Technologies. The software facilitates data acquisition using mobile consumer-grade biophysiological measurement devices, and communicates the processed data to a centralized server for the soundtrack generation. For V F C, we opted to acquire electroencephalography using the InteraXon Muse 2™ headset with 4 channels (2 frontal and 2 temporal).

Real-time signal processing

Several signal processing steps are carried out to interpret the biosignals acquired during the experience. Although each type of biosignal requires different care and analyses, most of these can be implemented by our platform and can be summarized by the following functions : cleaning the data from aberrant values, transforming the data into meaningful features, and comparing the data to sensible baselines. For EEG, our approach is to perform a spectral analysis to estimate activity within set frequency bands which are known to correlate with mental states and other psychological factors [5]. Then, these features are combined to produce meaningful indices of cognitive states and compared to baseline activity recorded during the introductory scene of V F C. The pre-processed features are finally sent to the centralized server for further processing.

Dynamic soundtrack generation

A centralized server receives the processed data of multiple users simultaneously. Based on an adaptivity-timeline provided by the creative team, the server-side software computes feature averages over relevant periods and uses a threshold-based approach to take user-specific decisions as to which parameter values to set for the incoming scene. These parameters are then used in a live audio production software to generate individualized soundtracks on the fly. Finally, a virtual soundcard is used to broadcast the generated soundtracks back to their corresponding device.

Future directions

The work hereby presented ventures into new avenues for movie writing by introducing non-linear adaptive elements to the movie content. The VFC Biomedix™ platform is flexible and can be extended to most types of wearable data acquisition devices, including but not limited to, EEG, EKG, EMG, EDA, PPG facial expressions recognition and eye tracking. Future works will take advantage of this multi-modality to further strengthen the connection between the cinematographic material and the spectator. The possibility of real-time modulations on a free-form material is another key prospect made available by our technology, pushing the personalization of the experience one step further by allowing more complex interactions and increasing degrees of freedom of the experience.

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Art pieces

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Ressources

A walkthrough of the UX is available at <https://vimeo.com/823790663?share=copy>. A demo of the companion web app can be found at <https://vimeo.com/870707341/afefdcfa94?share=copy>. The movie teasers are available at https://www.youtube.com/@VFC_experience-vr6se. The official poster artwork is hosted on <https://versionindustries.com/work/client/vfc>.

Authors Biographies

Antoine Bellemare is a transdisciplinary artist and researcher, working on creativity science as part of his doctoral work in computational and cognitive neuroscience.

Yann Harel is a researcher in cognitive neurosciences and PhD candidate in psychology, working on fluctuations of attentional states and videogames.

Philippe Lambert is a musician, interactive music composer, and interactive director. His work has been celebrated at film festivals like Sundance, Tribeca & IDFA and showcased at institutions such as La Gaieté Lyrique & MUTEK.

Charles Stéphane Roy is an award-winning film director and producer, working at the intersection of cinema and new technologies. He's the co-founder of SCINTILLA studio.