

# Time Giver: An Installation of Collective Expression using Mobile PPG and EEG in the AlloSphere

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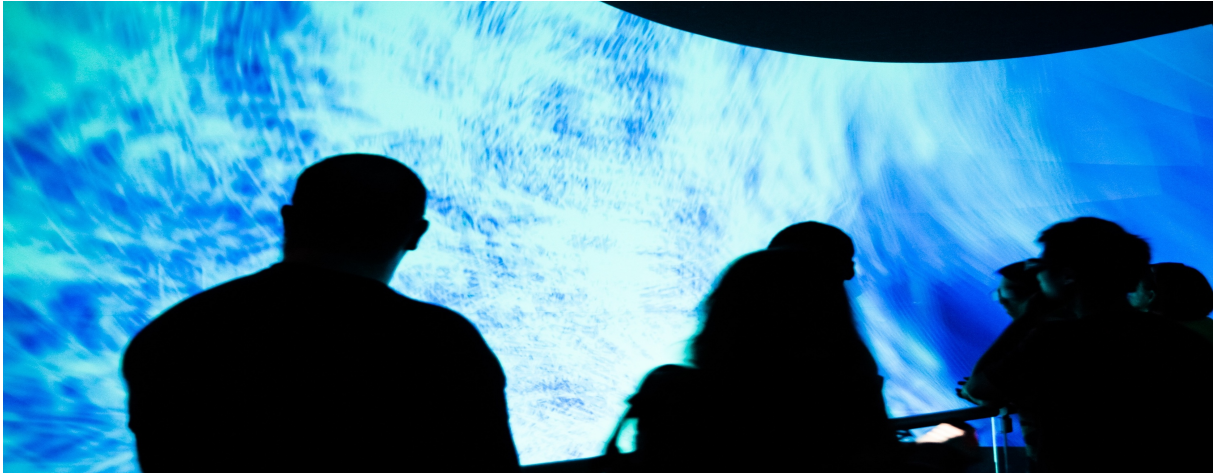


Fig. 1. Time Giver @ Shadows in Space, presented in the AlloSphere, California NanoSystems Institute, University of California, Santa Barbara, USA

**Abstract**—Time Giver explores the multimodal representation of an audience’s physiological (PPG and EEG) temporal patterns, shifting each audience member from spectator to active participant within the work. Using our BioSync interface running on personal mobile devices, each member of the audience is engaged and contributing in a collective creative work. This synchronous interaction provides a shared visual and sonic experience, taking place within the immersive environment of the AlloSphere, allowing for the dynamics of social and physiological triggers to relate to both the one and the many.

**Index Terms**—Audience, Biometrics, Mobile, Cybernetics, AlloSphere

## 1 INTRODUCTION

Time Giver is an artistic audiovisual installation that received its first public performance in the AlloSphere [3], a three-story immersive instrument and installation space at the University of California, Santa Barbara, on May 23rd, 2013. Time Giver is inspired by the German term *Zeitgeber*, which refers to “any external or environmental cue that entrains or synchronizes an organism’s biological rhythms to the earth’s 24-hour light/dark cycle and 12 month cycle [2].” Other common examples of *Zeitgeber* include light, temperature, social interactions, pharmacological manipulation, exercise, eating and drinking patterns. In designing Time Giver, we consider light, social interaction, and representation of temporal information as external cues to audience members within a dynamically evolving system generated using real-time data streams from the audience. Considering the AlloSphere as a closed system, each individual in the audience has his or her own biological rhythm, for example, heart rate and the ratio of alpha/theta bands from EEG data. As physiological data streaming is

made simple by our BioSync mobile interface [7], we explore artistic multimodal representation of temporal information from the audience in the AlloSphere. In addition to rhythmic information from individuals, social interaction is also a consideration, as *Zeitgeber* contributes to the dynamics within this closed system. To close the feedback loop, internal rhythmic information of the individual participant as well as the groups aggregate response are used to create real time stereoscopic visualization and spatial sonication in the AlloSphere.

The important concepts in the Time Giver project include:

- audience participation in the making of feedback-based artwork,
- an interface that enables exploring an artistic conversation between heart-rate monitoring and brain-wave monitoring,
- and an evolving system based on initial conditions determined by the timing of audience participation, manipulated by real-time feedback during the unfolding of the artwork.

The novel contributions of this research can be summarized as follows:

- a new technique that allows the creation of feedback-based artwork using biometric data from a large group of participants,
- a novel way to meta tag each participant with a unique smartphone ID using OpenSoundControl,
- and an affordable and scalable audience apparatus of bi-channel and bi-directional communication for feedback-based visualization and sonification.

This is our first experiment of collective expression using the BioSync mobile interface in an immersive environment.

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## 2 AUDIENCE AS CONSTITUENTS OF A SYSTEM FOR COLLECTIVE EXPRESSION

The present idea of audience participation in the interactive arts can be traced back to the 1960s. An early example is found in Roy Ascott's "change-paintings" [22]. Over the years, audience interaction [16] in the context of interconnected musical networks [31] has been facilitated by mobile technologies [15, 32, 14, 8], computer vision techniques [10], web technologies [25, 24], ubiquitous sensing [9, 21], social networking [20, 6], and the trend of convergence of continuous rating and physiological sensing [5, 17, 13, 12, 4]. AlloBrain project initiated "interface experiments proposing to explore how visualized and sonified EEG data can be integrated into a real-time interactive environment with biofeedback" [30]. The novel solution presented in this paper allows us to further explore real-time visualization and sonification using biometric data from a group of participants with convenient mobile biometrics.

To explore ways to collect information from the audience at a live performance or interactive installation, a modern mobile device like a smartphone has various built-in sensors and is convenient to program applications that can stream data to other applications. With real-time data from the audience, the composer starts to consider audience participation as a compositional technique [11]. In the Time Giver project, the same interaction technique is applied and it aims to explore ways to represent temporal information from participants in a conceptually enclosed feedback system. As a constituent of the system in Time Giver, each participant in the audience contributes to the dynamics of the system via a smartphone in real-time. There is a unique bi-directional communication in Time Giver, in that each individual is also informed by the groups aggregate response via network broadcasting in the same time as he or she sends out rhythmic information.

Collaborative task performance has become a well-discussed topic in such journals and conferences as Computer Supported Cooperative Work and Social Computing (CSCW), and is an important aspect of Time Giver because it aims to explore artistic multimodal representation of real-time data streams from a large group of participants in an immersive environment. The participants work in collaboration in unfolding the artwork. In our first attempt, the experiment carries out an ecological system whose audiovisual representation evolves over time and depends on the dynamics of the crowd. The unique aspect of Time Giver is that it uses multiple types of biological information gathered from the participants as a group to realize the multimedia artwork.

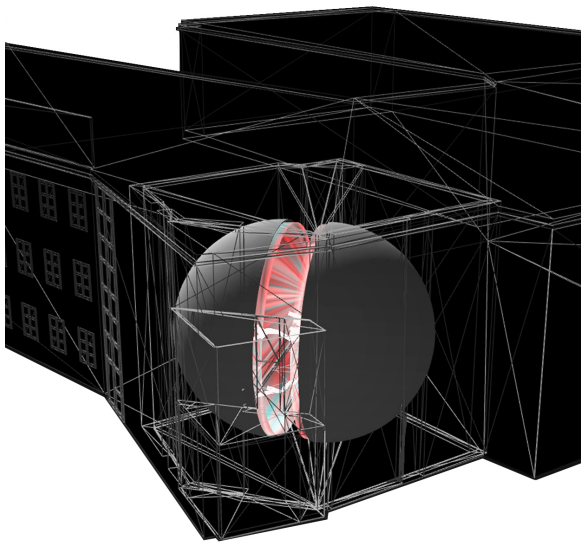


Fig. 2. The Allosphere at the California NanoSystems Institute, University of California, Santa Barbara

## 3 DESIGN CONCEPT OF TIME GIVER

The design of Time Giver consists of the audience, the AlloSphere, an audiovisual synthesis engine (AlloSystem C++ toolkit [23]), and mobile biometrics (BioSync iOS app [7] with MindWave Mobile [19]) and Max Msp[1] for data collection and broadcasting. The output of the system is a collective expression of 3D stereographic video projection and 54.1-channel 3D spatial sonification. The multimodal representation from the system output is a function of rhythmic information from audience biometrics as well as the dynamics of the crowd. Biometrics from the audience refers to heart-rate and ratio of Alpha/Theta bands from EEG, and is captured using mobile devices.

### 3.1 Multiple Users in a Controlled Environment

In designing Time Giver, we explore the role of audience participation and biometrics as an interactive installation within the AlloSphere. Conceptually, we think of audience as constituents of a dynamic system that generates artistic audiovisual content in a controlled immersive environment. The AlloSphere offered a controlled, closed performance space that facilitated a fully multi-user immersive experience.

The AlloSphere, a 30-foot diameter sphere built inside a 3-story near-to-anechoic (echo free) cube with a custom-built close-to-spherical screen, allows for synthesis, manipulation, exploration and analysis of large-scale data sets in an environment that can simulate virtually real sensorial perception [3]. Designed to accommodate a group of multiple users, it was an ideal test bed for the first audience-based performance of Time Giver.

### 3.2 BioSync Mobile Interface

The BioSync iOS app [7] enables convenient biometric data collection from the audience. The BioSync app merges the paradigms of heart-rate and brain-wave into one mobile unit which is scalable for large audience real-time applications. It collects the users heart rate via mobile device pulse oximetry and the EEG data via Bluetooth communication with the off-the-shelf MindWave Mobile hardware. A mobile dual-channel pulse oximetry and EEG bi-directional interface for the iOS device (BioSync) was designed and developed. Time Giver is the first experiment of collective expression using the BioSync mobile interface in a controlled immersive environment.

With our informed participatory biometric interface (BioSync), each individual contributes to audiovisual content creation while being informed of the crowd's average response in the same time. Depending on the number of checked-in users, a running average is performed on both incoming heart rate and EEG signal data streams. The average of the group's response is then sent to clients in OpenSoundControl format. The bi-directional communication in Time Giver is achieved via network broadcasting under a local area network.

### 3.3 Visualization and Sonification in Time Giver

Biometric data from each audience member is considered as an object that has its own aural and visual representation within the enclosed spherical environment. We consider rotation of objects and the enclosed spherical environment as metaphors that relate to ideas of cycles and rhythm of time in Zeitgeber. Time tag of audience check-in were collected and used to determine the initial condition of the audiovisual system as well as the unfolding structure of the artwork. For dramatic perceptual effects, rhythmic information from audience was used modulate the initial audiovisual representation during the unfolding of the artwork. The behaviors of these objects are determined by rhythmic information from the crowd and the audiovisual experience of Time Giver is unique to dynamics within the crowd during performance.

#### 3.3.1 Visualization

This section gives a description of parameters we used for real-time visualization, including number of connected users, the time tag of each user and running averages of both heart-rate and EEG Alpha/Theta ratio for each user.

The visual design of Time Giver concerns itself with the sense of immersion within the AlloSphere and the connection of visual objects

determined by audience participation. The number of connected users and the time tag of the checked-in user determine the initial conditions for the visual complexity in the artwork. To associate rhythmic information from the audience to the idea of a Zeitgeber cycle, we mapped heart-rate to the rotation of the objects spherical texture. The sense of immersion is achieved by the use of a virtual camera in the center of the sphere so that audience standing on the AlloSphere's 2nd story bridge perceives cyclic movement of each visual object. With multiple participants, the overlay of transparent spherical textures rotate around the audience while the level of extrusion in the third axis is a perceivable effect of the group's aggregate response.

Biometric data from each audience member is mapped to motion and transformation of spherical texture objects. The number of spherical texture layers depends on the number of clients connected. For example, the number of spherical textures increases whenever a new client checks in to our server using our mobile app. The radius of the spherical texture also increases as the number of connected clients increases. In addition to transformations and rotations, the level of extrusion of the spherical texture is controlled by a running average of all checked-in users heart rates. The eye separation for distance for stereographic rendering is also controlled by the ratio of EEG Alpha/Theta bands from connected users. With stereographic video projection in the AlloSphere, Time Giver presents a 3D visual system that evolves in synchronization with rhythmic information from the audiences biometrics.

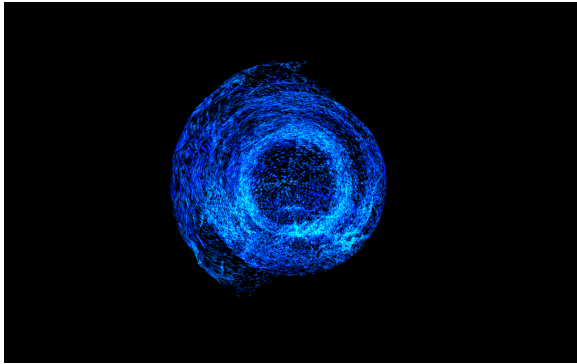


Fig. 3. The level of extrusion of each layer is determined by the group's aggregate response.

### 3.3.2 Sonification

The sonification of TimeGiver is conceived around the temporal notions of the collected interactions. The bases work by establishing a fundamental rhythm found within the lowest frequencies (normally 55-120 Hz) as a Zeitgeber Cycle. This is composed of a running average of all checked-in users' heart rates, and is updated at sample-rate. This provides a low smooth sine wave that unifies the space together that is sonified through a Meyer Subwoofer at the bottom of the AlloSphere. This ambient tone of the environment is layered with the running average of combined users EEG data. These independent oscillators iterate through the respective frequencies of Alpha/Theta that are treated as sets. Each EEG band is sonified using FM synthesis, where the fundamental frequency is the current running average while the modulation is controlled by the running peak and the modulation magnitude is controlled by the number of checked-in users.

There are selected filters that are utilized for triggers of certain events during the course of the interaction. These include the amount of reverb and delay within the given composition and selected meta-chords, which are made of the shifting selection of the users' EEG alpha/theta bands, where alpha is mapped to the delay time and theta is mapped to the amount of reverb. A running average of alpha/theta is mapped to the amplitude of each and the whole composition is spatialized in 3rd order Ambisonics[29] through the Allosphere's 54.1-channel Meyer sound system.

## 4 ARTISTIC CONTRIBUTIONS IN USING EEG/PPG DATA IN MULTIMEDIA ARTWORKS

Driven by the interest of using the bio-sensing paradigms of the heart and the brain in the generation of multimedia art, Time Giver is our first experiment in creating an artistic conversation among the rhythmic information sources of the human bodies of a collective audience. Biometrics has been used for multimedia artworks, such as Being Invisible [27], Music for a Solo Performer and Homuncular Homophony[26]. David Rosenboom's work generated a firm foundation in the generation and analysis of the electro-biological arts and represented rational modalities and understanding of these biological oscillators in the production of art and the interest in what motivates the way we perceive, learn and connect to the arts.

Our approach is novel in scaling up the type of conversation from the one-to-one, to the one-to-many, in an affordable and efficient way. By creating 2-way communication within the system, Time Giver informs the users of both their own personal biometric status and the running average of the entire sampled audience and thus experiments with a new and active method of designing multimedia artworks that use bio-signals. With mobile biometric tools such as the BioSync interface, Time Giver allows the ability to explore artistic representation of collaborative heart-brain conversation in a scalable fashion.

## 5 EVALUATION AND FUTURE DIRECTION

Time Giver was part of the AlloSphere public exhibition "Shadows in Space" on May 23rd, 2013. It was shown twice, and each time, the size of the audience was roughly 20 to 25 people on the bridge. In terms of audience participation, the most challenging logistical problem was to instruct every participant to download our mobile app before coming into the AlloSphere. Instead of a native iOS application, such a problem might be able to be resolved using a browser-based application once an external accessory framework is also supported. This application is currently being developed.

Future research and evaluation of Time Giver will include experimentation in open public spaces where the environment is not closed and controlled as within the AlloSphere instrument. Understanding effects of various mapping strategies on audience perception and its consequence within feedback loops is of great interest to us. Various performance configurations will also be explored, as the sense of immersion will be less in a larger public space, however audience movement and grouping may be better exploited as a performance mechanism in larger open environments which included spatial tracking and movement patterns.

## 6 VISUAL DOCUMENTATION FROM SHADOWS IN SPACE 2013

The following visual documentation are from the first public showing of Time Giver at the Allosphere. Shadows In Space was held at the on May 13, 2013 at the

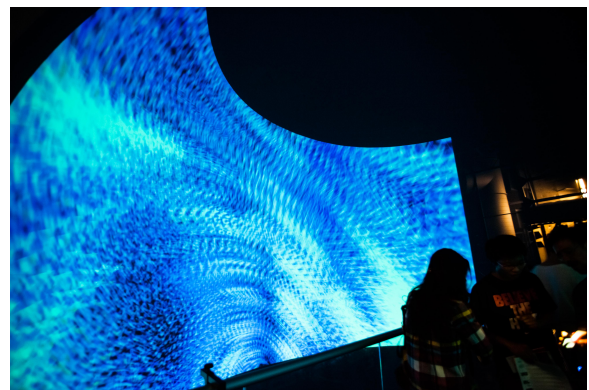


Fig. 4. Front projection in the AlloSphere

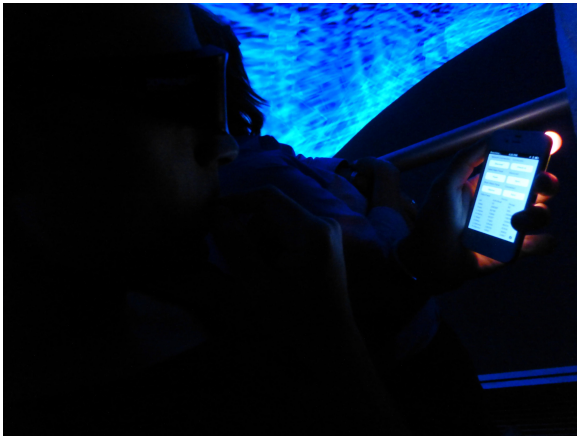


Fig. 5. A user interacts using the BioSync interface at Time Giver installation in the AlloSphere

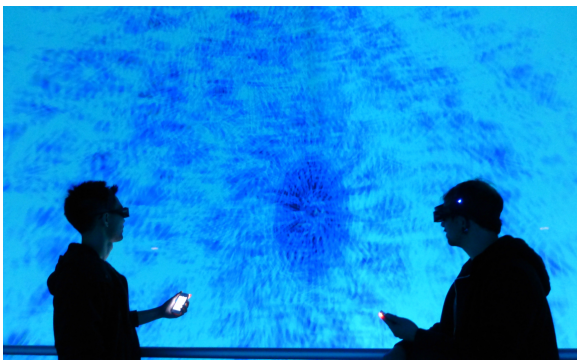


Fig. 6. Two users interacting with Time Giver in the AlloSphere

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