To be inside someone else's dream: On *Music for Sleeping & Waking Minds*

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ABSTRACT
Music for Sleeping & Waking Minds (2011-2012) is a new, overnight work in which four performers fall asleep while wearing custom designed EEG sensors which monitor their brainwave activity. The data gathered from the EEG sensors is applied in real time to different audio and image signal processing functions, resulting in continuously evolving multi-channel sound environment and visual projection. This material serves as an audiovisual description of the individual and collective neurophysiological state of the ensemble. Audiences are invited to experience the work in different states of attention: while alert and asleep, resting and awakening.

Keywords
EEG, sleep, dream, biosignals, bio art, consciousness, BCI

1. INTRODUCTION

In her discussion of Bill Viola's *Sleep of Reason* (1988) – an installation that intersperses long segments of video of a sleeping man's head with brief interludes of nightmarish images and loud noises – the cultural theorist and critic Mieke Bal asks: 'To be inside someone else's dream: could that not be a definition of the experience of art'? [1] Indeed, much of the art of the last century (in particular) can be seen as belonging to the repository of dreams: a record of dreaming, a meditation on the dream, an ode to the dreamer. (See Gamwell 2000). [2]

This art is often representational, conveying dream imagery or images of sleep. Andy Warhol's first film, *Sleep* (1963), a five-hour film of the poet John Giorino sleeping, is a celebrated example. Other works do not necessarily represent sleep or sleep states, but are instead posited as productions of the 'subconscious' or 'unconscious' mind: works that result, for example, from the use of chance methods, or the automatistic methods favored by Surrealists and Dadaists. In other cases, sleeping itself is performed for an audience. In his *Dream Event* (3-5 December 1971), the Fluxus artist Geoffrey Hendricks fasted, slept, and kept a log of his thoughts for forty-eight hours in a Manhattan gallery. For her work *Slumber* (1993), the Bahamian artist Janine Antoni slept in the Guggenheim Museum in New York City for several weeks. An electroencephalograph (EEG) machine recorded Antoni's brainwaves, producing patterns that she subsequently wove into the blanket under which she slept. In more rare examples, audiences themselves have been invited to sleep as part of an artwork. From 25 October 2008 to 6 January 2009, the Guggenheim accepted overnight reservations for Carsten Höller's *Revolving Hotel Room*, an installation in which the interior of a hotel suite was mounted on a rotating platform inside the museum. Participants in *Revolving Hotel Room* could, ostensibly, have their own private sleepover at the Guggenheim.

Music for Sleeping & Waking Minds (*MS&WM*) is a new work that belongs to, and in some ways diverges from, this rich lineage of sleep and dream-based art. Composed and conceived by Gascia Ouzounian, and featuring physiological interface and interaction design, and audio/video behaviors by R. Benjamin Knapp, audio interface and interaction design by Eric Lyon, and visual interface and interaction design by R. Luke DuBois, *MS&WM* invites audiences and performers alike to fall asleep and awaken to sounds that are generated by the brainwave activity of four 'performers'. During the course of one night, the four individuals fall asleep and awaken as they naturally would. As they do so, their brainwaves generate and process sound and image. This sound emerges as a continuously evolving, dense electronic drone made up of multiple tones whose aural characteristics (timbre, spatial location, frequency, duration, amplitude, etc.) evolve in simple and minute ways according to changes in brainwave activity; the sound environment is projected over eight loudspeakers that surround audiences. The visual projection, which is similarly derived from EEG signals, follows a parallel process in light and image. Audiences, who are invited to bring anything that they need to ensure comfortable sleep, can experience the work in different states of attention.

In translating the brainwave activity of sleeping performers into an immersive environment, *MS&WM* literally invites listeners to be inside someone else's dream: a collective dream that is at once performed, represented, and produced within and between multiple states of consciousness, and articulated in sound and light.

2. COMPOSITIONAL ELEMENTS
MS&WM can be thought of as an audiovisual description of the individual and collective neurophysiological states of four individuals. It is perhaps unique in the NIME community in that the performers' only task is to sleep and awaken while wearing EEG sensors. The data gleaned from the EEG sensors is transmitted to computers that show a visual representation of each performer's brainwave activity (in the EyesWeb software environment), and apply these brainwave signals in real time to

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different audio and image signal processing functions (in Max/MSP and Jitter).

In the first presentations of *MS&WM*, which took place in the summer of 2011, the synthesized sound comprised a set of sixteen sine tones that were modulated by the ensemble's brainwave activity. Each performer was assigned four tones at the outset of the event, and each was brought into the mix in turn (at around 10 minute intervals), such that his or her contribution to the overall mix could potentially be identified. The thought was that these staggered entrances would allow listeners to observe the ways in which each performer contributed to the emerging 'collective consciousness' that was being described in sound. This emergent consciousness – one that could be heard simultaneously within multiple states of attention was neither predictable nor controlled. It evolved as a kind of dialogue between minds, a dialogue that was simultaneously 'conscious' and not.

As an artwork, *MS&WM* is principally concerned with perception and communication, specifically as these emerge within and between different states of attention: How does our perception of sound and light change between different states of attention, and how is this shift experienced (physiologically, emotionally, etc.)? How do we communicate these experiences, and what are the terms of our communications?

The decision to base the composition of *MS&WM* on a rich, mostly static synthesized drone emerged for a number of reasons. In the first instance, the work was conceived as the second in a series of overnight compositions. In the first of these, *EDEN EDEN EDEN* (2009), an audiovisual work by Gascia Ouzounian and filmmaker Chloe Griffin, an ensemble of musicians constructs and deconstructs a harmonic series over the course of about six hours, continuously tuning and detuning the series according to a predetermined process. In using a continuously evolving drone as the basic musical material of both compositions, the idea was to allow listeners to project their own perceived structure upon the work rather than experience it according to more defined or definite structures. In contrast to more segmented musical forms, the drone also serves as a more flexible accompaniment to the listener's imagination and thoughts (or sequences of thoughts), which may be of any duration, and which might emerge or fade at any stage.

In this sense, *MS&WM* is more closely aligned with works that 'invite the dreamer to dream' rather than depict or define particular dreams – the Finnish artist Maaria Wirkkala's *Dream Screen*, for example, which consisted of a large black rectangle on the surface of a gallery wall. 'By transforming the blackness into a surface on which to view oneiric projections in the night, [Wirkkala] presented [*Dream Screen*] as not a physical, "literal" surface but as an expanse filled with meaning' (Gamwell 2000: 31) [3]. It owes a particular debt to La Monte Young's conception of continuous periodic, composite waveform environments; his idea of a 'drone state of mind'; and Young and Marian Zazeela's *Dream House*, 'a time installation measured by a setting of continuous frequencies in sound and light' currently in its nineteenth year of exhibition in lower Manhattan (see Young and Zazeela) [4].

The drone basis of *MS&WM* also allowed for changes in individual performers' brainwave activity to be articulated in perceptible ways, while at the same time providing a continuous field of sound that would ideally promote, rather than disrupt, sleep among participants and audiences.

Figure 1. Audiences at the premiere of *Music for Sleeping and Waking Minds*. BEAM Festival, Uxbridge 25-26 June 2011. Photograph by Gascia Ouzounian © 2011.

3. MAPPING SLEEP TO SOUND

3.1 Background

Techniques for deriving states of consciousness during sleep by measuring brainwave activity began over a half century ago with the work of Loomis, et. al. [5]. Using an array of electrodes across the scalp, Loomis measured the change in electrical activity using the electroencephalogram (EEG) during sleep and determined that there were specific patterns that repeated themselves over the course of the night. Since then, these patterns have become known as the five stages of sleep: stages 1-4 and Rapid Eye Movement (REM) sleep [6]. Sleep stage 1 corresponds to when the eyes are closed and the individual is drowsy. It is identified by the presence of 8-12Hz waves (alpha waves) within the EEG. Sleep stage 2 is the predominant sleep stage during the night and is noted by the diminishment of the alpha waves as well as the appearance of random signal bursts in the region of 12-16Hz known as sleep spindles (and associated k-complexes). Stage three begins the appearance of slow waves around 4-8Hz known as delta waves. Stage four sleep is known as 'deep sleep' and is only differentiated from stage three by the quantity of the delta wave activity. REM sleep, often (although not exclusively) associated with dreaming, is noted by bursts in the EEG caused by the eyes darting back and forth (EOG).

Over the course of a night, roughly every ninety minutes, a normal sleeper will cycle through these stages. As the night progresses, the typical sleeper will experience less and less deep (stage 4) sleep and will move back and forth between the other stages in a less sequential pattern, even waking up from time to time. (For a good overview of sleep staging and the EEG see Carskadon and Rechtschaffen, 2005) [7].

3.2 The Hardware Configuration

As previously mentioned, *MS&WM* has four 'performers' whose brainwaves drive the 8-channel electronic soundscape of the piece. As seen in Figure 2 below, each performer wears a single headband from Infusion Systems (www.infusionsystems.com) that contains three dry electrodes placed on the forehead for measuring the frontal lobe EEG. This placement also enables the electrodes to pick up the EOG associated with REM sleep. Inside the band is also a bi-axial accelerometer for measuring motion of the head. The band and the accelerometer are connected to a Bluetooth radio to transmit the data to a PC running EyesWeb software that, in real-time, combines the data streams from all four performers, extracts the relevant features of the EEG and the motion signals and then send the data to a second PC running Max/MSP to map these features into sounds of the piece.

Figure 2. Four 'performers' wearing headbands containing EEG dry electrodes and 2D accelerometers. Diapason Gallery, New York City, 4-5 June 2011. Photograph by Gascia Ouzounian © 2011.

3.3 The Mapping Software

As shown in **Figure 3**, the auditory representation of the sleep stages of the performers relies on continuous mappings of the EEG and accelerometer signals to parameters of a constantly changing 8-channel soundscape. The soundscape consists of sixteen tones of variable spectrum. Each performer influences four of these tones. As a performer enter sleep stage 1, the presence of alpha waves applies tremolo to the four tones assigned to that performer. As the performer slowly transitions to sleep stage 2, the tremolos decrease. At the same time, the beginning presence of sleep spindles triggers enveloped tones processed by delays with feedback. As the performer moves into stage 3 sleep, the presence of slow wave (Delta) activity reduces the timbral complexity of each of the tones. When the performer finally reaches stage 4 (deep) sleep, the complexity is at its minimum. Also, each time a performer reaches this stage, one sine tone is removed from the four tones. This means that if the performer achieves deep sleep three or more times in a night, only one tone will be present at the end. This enables listeners to not only experience the changing soundscape within one sleep cycle, but to experience through sound the increasing rest that occurs for the performer over the entire night. In REM sleep, the performer's eyes are darting back and forth and higher frequency beta activity is present. To represent this, the sounds mapped from that performer are cycled across the octophonic array. The extreme simplicity of the sonic mappings allows any patterns that emerge to be heard as clearly as possible during the performance.

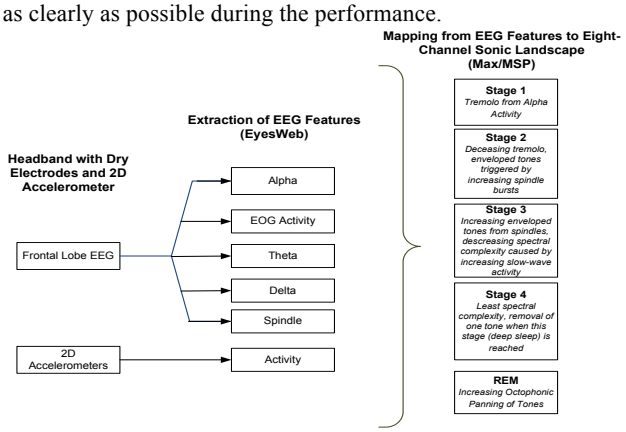

Figure 3. The MS&WM Architecture: The components of the process (1) data acquisition using a headband on each of four performers, (2) the extraction of the acquired signals into sleep staging features and (3) the mapping to the octophonic soundscape

4. PERFORMANCE

Though awake, one remains under the spell of the dream…
-Walter Benjamin, *One-Way Street* [8]

MS&WM was presented on three occasions in the summer of 2011. A preview performance was given on 4-5 June at the Diapason Gallery in Brooklyn, as part of BioRhythm: Music and the Body series hosted by Science Gallery Dublin for the World Science Festival. On 25-26 June, it was premiered at the BEAM Festival in Uxbridge; this performance was followed with a breakfast Q&A with audiences. A third performance, which was also followed by a Q&A session with audiences, took place at Green Man Festival in Wales on 20-21 August.

On all three occasions, the four performers were volunteers – friends, colleagues, and strangers who offered the use of their brainwaves for a night. The performances took place in very different settings: an intimate sound art gallery with a large picture window overlooking the Brooklyn Bridge, where visitors could sit on chairs and sofas, or sleep on carpeted floors; a large, darkened auditorium where about forty mattresses were laid out for audiences and participants; and a large tent in an outdoor festival, where most audiences were prepared to camp for the weekend. On each occasion audiences were invited to bring what they needed to ensure comfortable sleep if they were planning to stay for the duration.

Due to the particular exigencies of the work, the preview performance at the Diapason Gallery was the first time the authors were privy to how *MS&WM* might work outside the studio setting. We had undertaken different tests in the studio to learn how different kinds of brainwave activity might result in different kinds of sound, and had recorded data relating to individuals' brainwaves during different stages of the Sleep-Wakefulness Cycle (SWC) in order to test this in studio. Still, the particular dynamics of an 8-hour performance featuring four performers (all with unique, unpredictable sleep patterns) remained unknown until the time of performance.

In each of the performances, we had both 'light' and 'heavy' sleepers. The light sleepers woke quite often throughout the night and very rarely encountered deep sleep. This caused the presence of frequent tremolo activity from fading in and out of drowsiness (stage 1) sleep. Frequent, rapid spindles from stage 2 sleep were also prominent. Since 'light' sleepers never reached stage 4 sleep, their four tones were always complex and no tones were removed from their initial allotment of four. On the other hand, the 'deep' sleepers almost never woke up and reached stage four sleep several times throughout the night. Thus, they created an almost perfect counterpoint to the 'light' sleepers. Frequent REM activity caused the sound to cycle from speaker to speaker. By being frequently in stage 3 sleep, they caused long slow spindles to appear. With the slow-wave activity, the timbre of their tones were simplified and, by the end of the evening, they were left with only one note from their original four – sonically revealing the restful night they experienced.

Notably, the authors (who monitored the sleepers' brainwave activity throughout the different performances) observed that members of the ensemble perceptibly responded to changes in their sound environment within the different stages of the SWC. In the context of this work, such a response can perhaps be posited as a kind of communication or exchange between the members of the ensemble, and between the ensemble and its environment. We also observed that, within the larger context of the continuous sound environment, sudden or vivid changes

(for example, an unexpectedly loud spindle event) did not typically awaken the sleepers, although some reported a sense of being continuously 'pulled into' and 'out of' sleep throughout the night, i.e. kept in a liminal state between sleep and awakening through changes in the sound environment.

Audiences reported a multitude of different experiences that ranged from intense to restful to blissful to oblivious. Many reported vivid, imagistic dreams. Several commented that, despite being immersed in the sound environment continuously for many hours, following the performance they had little recollection of 'what it sounded like'. Others commented on the uniqueness of the collective sleep experience and of experiencing sound and music in their sleep. One listener/participant, a composer of electronic music, described her experience thus:

> 'It was soothing music, semi-monotonous but continually evolving, with enough elements particularly when spatialized to generate a need for conscious or subconscious attention. If concentrating, one could get a sense of a feedback loop, with the sound correlating with physical state; but this sensation was rather alien since the correlation was not with bodily change of position or anything apparent; rather the sound patterns were coincident with changing states of brain activity of which most of us are not typically aware. For me there was some sense of relation, i.e. even deliberate control of/generation of sounds. It was a bit Borg-like since the interconnected sonified mental web of the collective lying on the floor was externalized, or embodied, as a unified sound composition in the entire room. I suspect that the composed nature of the structure, and the specific sounds [that were] selected fostered this sensation'.

In the Q&A sessions and conversations that followed the different presentations, listeners were particularly curious as to how different aspects of the SWC were articulated in sound, and whether or not things like nightmares could be discerned in the sound environment. Performers wanted to know more about their particular sleep patterns and whether they had 'performed well' (since the composition was designed to accommodate any kind of sleep pattern, there was no 'better' or 'worse' performance on the part of the performers themselves).

In future performances we plan to experiment with different audio/video DSP functions and compositional structures in the work, which is in a sense a 'model' or framework than a strictly determined composition. The performance at NIME 2012 will be the first to feature visual projections; we are also planning to develop an immersive installation model in collaboration with the British artist Kate Genevieve, which will explore, more specifically, aspects of the audience's collective sleep experience.

5. CONCLUSION

In her essay 'The Muse is Within: The Psyche in the Century of Science', Lynn Gamwell (2000: 55) predicts that 'artists of the next century will be inspired by an awesome new concept of dreamwork that fully integrates neurology with the subjective experience of the self' [9]. *MS&WM* is an attempt, still in its early stages, at putting neurophysiological science to the service of music and image that are born of, and that give form to, the dream, the process of dreaming, and to dreamers. When Sigmung Freud (1913) [10] introduced the concept of the dreamwork as the process whereby the mind produces the manifest dream, his theory inspired not only psychoanalytic communities, but myriad artistic communities as well (see Ruhs 2000: 9) [11].

In Ouzounian and Griffin's overnight work *EDEN EDEN EDEN*, the continuously evolving patterns of sound and image were conceived as a 'memory processing ritual'. The programme notes read:

> 'Aural and visual acts become chaotically resonant through their continual repetition. Members of the audience, who are invited to sleep during the performance, shift between waking and dreaming states. Afterwards, their memories coincide.' (Ouzounian and Griffin 2009) [12]

EDEN EDEN EDEN proposed that the collective experience of continuous, repetitive, and continuously evolving patterns of sound and image within different states of consciousness could enable co-incidental 'resonant' memories to emerge. *Music for Sleeping & Waking Minds* proposes that communication (understood in its broadest sense, as the exchange of thought) can occur simultaneously within and between multiple states of consciousness, and that an intelligent, shared consciousness can emerge from this communication. Although this idea is still in its nascent stages and is shaped through an entirely experimental approach, it encourages a new understanding of the dreamwork as a shared experience, and of the creation of music as viewed through the lens of a collective dream.

6. ACKNOWLEDGMENTS

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8. APPENDIX

For video excerpts of *EDEN EDEN EDEN* and *Music for Sleeping & Waking Minds* please see http://vimeo.com/gascia