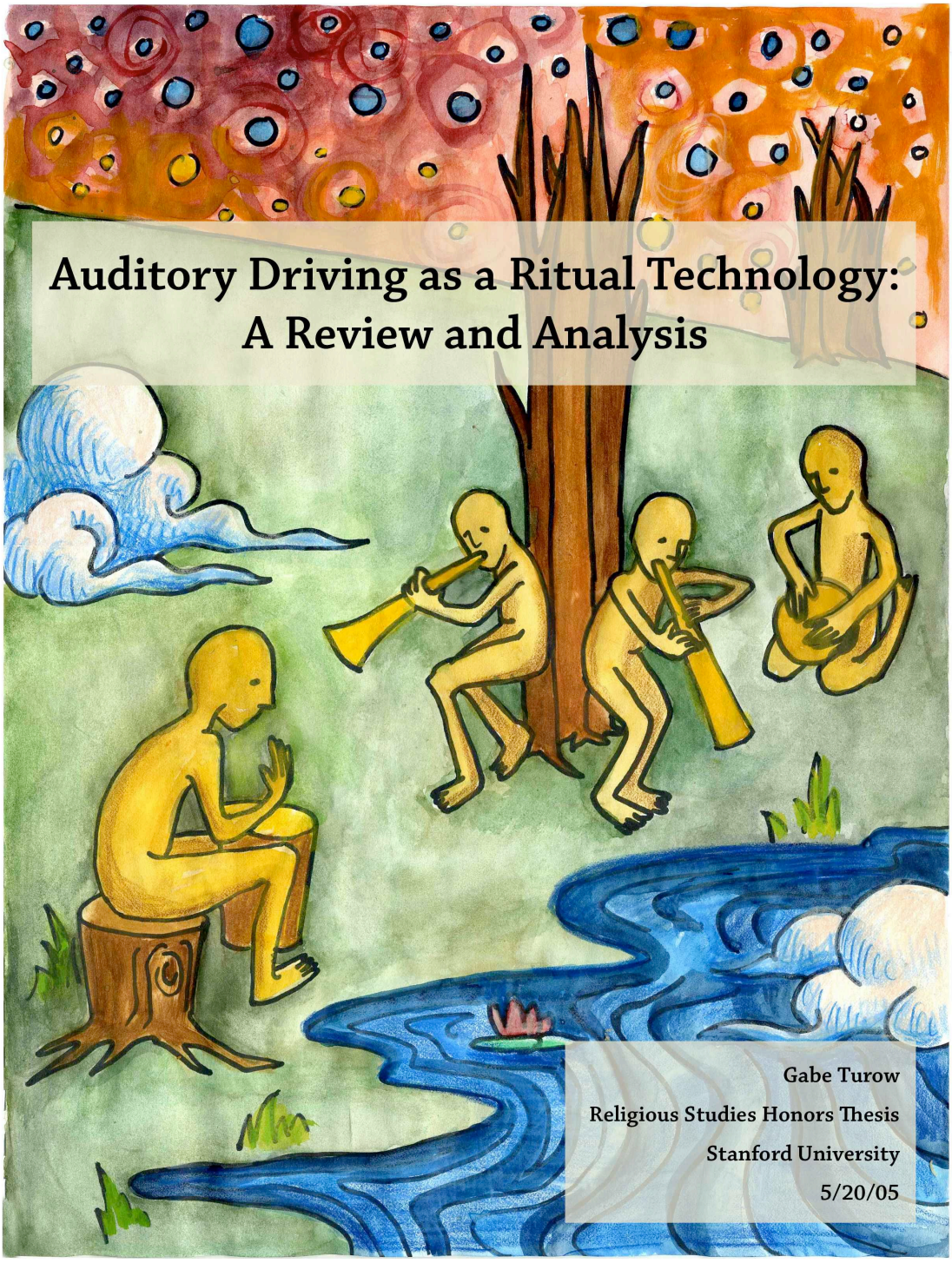


Auditory Driving as a Ritual Technology: A Review and Analysis

Gabe Turow

Religious Studies Honors Thesis

Stanford University

5/20/05

Acknowledgments

Liz. You were everything for this project. My thanks are endless.
Prof. Eisen, Prof. Mancall, Prof. Berger—you kept me going, kept encouraging me. I couldn't have finished this without your support.
Dr. Kushida, Chia-Yu, Eileen—you guys are too awesome! Thank you so much for letting an unwitting undergraduate into your lab.
Friends and Family—thank you for stoking my insanity.

Table of Contents

CD Notes

When you encounter an * during Chapter 5, play the track by its name. They are categorized by CD.

***Anthology of World Music, The Music of Tibetan Buddhism*. Disc 2. Rounder CD: Rounder Records Corp. Copyright 1999.**

1. Track 1, "History of the Sakya religion"
2. Track 8, "Prayer for the Dalai Lama"
3. Track 9, "Doctrine concerning the afterlife"

***Anthology of World Music, The Music of Vietnam*. Rounder CD: Rounder Records Corp. Copyright 1999.**

4. Track 7, "Recitation of Buddhist prayers"

***The Early Morning Great Bell Verse*. <http://www.buddhanet.net/audio-chant.htm> Buddha Dharma Education Association, Copyright 2004. 12/2/04.**

5. "The Early Morning Great Bell Verse"

***Drops of Emptiness: Songs, Chants, and Poetry from Plum Village*. Sounds True: Sounds True. Copyright 1997.**

6. Track 2, "Prelude to Sitting Meditation"

***One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan.* Ellipsis Arts…: Ellipsis Arts… Copyright 2000.**

7. Track 1, "Morning bell chant"
8. Track 5, "Mandel Tachen (Great Melody Mandala Offering)"
9. Track 6, "Hyakuhachisan"

***Anthology of World Music, The Music of Vietnam*. Rounder CD: Rounder Records Corp. Copyright 1999.**

10. Track 8, "Buddhist Chant"

***The Gyuto Monks: Freedom Chants From The Roof of the World.* Rykodisc: 360 Degree Productions. Copyright 1989.**

11. Track 1, "Yamantaka"

Chapter 1: Introduction and Overview

A. Introduction:

This project began about a year ago, during a party on campus. I was playing drumset in the blues band that had been hired for the evening. By about two hours into the show, everyone was dancing, it was loud and raucous, and I was thoroughly warmed up. As one of our guitarists finished his solo, he spun around, nodded at me, and said, "Go for it." Although I don't generally take a lot of drum solos, I didn't hesitate. I broke into a rhythm and started building it up on the snare and bass drums. Then, without any warning, I found myself perched about five feet off the floor and about four feet behind my body, looking down at myself at a slight angle. The music kept going, and after about twenty seconds I started thinking, "Wow, this sounds pretty good," and then suddenly realized that it was me that I was watching and listening to. Immediately, I was back in my body, seeing the drums again from their normal angle, aware that I had to keep playing or everything was going to fall apart. It was such a strange experience that I didn't mention it to anyone in the group, but I can still remember it as vividly as if it just happened. Afterwards, there was no doubt in my mind that there was more to what I was doing than just playing the drums.

This experience sent me into a fit of reading about percussion and altered states of consciousness that has only expanded and become more meaningful the longer it's gone on. Once it became clear to me that altered states and music making were intimately related, I began to notice the variety of subtler altered states I'd been experiencing. An occasion shortly after the one I just described was another milestone in this process.

I'd been reading and thinking a lot about "flow" at the time, the term coined by Mihaly Csikszentmihalyi in his book on creativity and optimal experience,[1] and I started to try to notice when I was in that sort of state on the drums. Looking back, I'd been having this sort of experience for very brief periods as long as I could remember, but only about a year prior to this story did those periods start to get longer and more pronounced. It's clear now that over the years I had been going through the process of getting my technique to a place where I didn't have to think, "right hand, left hand, right hand, right foot, left hand, right and left together, etc." all the time. It was a trajectory, that I'm still on today, towards singing my parts to myself and playing them in the same moment, without any specific thoughts about what my body was supposed to be doing in three-dimensional space. The show that I'm about to describe was one of the first times that I entered this state and was immediately able to appreciate what had happened.

The night started pretty badly. I'd had a fight with my girlfriend, and then the setup for the gig took longer than expected. We worked right up until the start of the show, and I was not in a good frame of mind to play music. About two or two and a half hours into the show I had a major shift in consciousness. I don't know what triggered it, but I stopped thinking about my girlfriend, and my frustrations, and my playing completely changed. It was something I could feel. My whole body began working as a unit, I felt loose, and my playing became much cleaner, subtler, and more energetic. It was such a drastic change from how I'd been playing even five minutes before, that I actually pulled myself out of the experience enough to note how different and amazing it was. After the gig was over, I talked for a long time with some friends of mine about what had happened, and how I knew I'd undergone some kind of shift in consciousness

[1]Csikszentmihalyi, M. "Flow: The psychology of optimal experience." (1990). NY: Harper & Row.

that had led to a very different real-time experience of the music, the players around me, and my own body.

As the next couple of months passed, my ideas opened up even more. I suddenly realized that the type of concentration and focus that Csikszentmihalyi described had everything to do with kinds of focus I'd been learning about in my Buddhism classes during discussions of various meditations. Drumming forced me to focus for an extended period of time on one object, the beat, just like concentration meditations on the breath or an image. At other times, especially when I practiced, playing was more like insight meditation, where I would get in a groove and let my thoughts flow, rather than concentrating and keeping them still. These times had always been a productive way to think through whatever was on my mind. And I was constantly reciting a mantra, "1, 2, 3, 4, 1, 2, 3, 4…" It became clear to me that I'd been learning to mediate for all 12 years that I'd been playing, and that recently, something about it had changed, maybe in a similar way to the kinds of descriptions of different levels of meditation I'd read about. Either way, I began to glimpse something about myself and my playing that I hadn't seen before.

These days, it's much clearer. No matter what state of mind I'm in before I play the drums- happy, depressed, anxious, frustrated, excited- after 15 minutes of playing a groove with a couple of permutations, I can stop and feel totally clear-headed, calm, and energized. If it's an altered state I'm inducing, I've gotten very good at it. And although I haven't had another out-of-body drum solo since the one I described, I've experienced many other states of mind on the drums that are categorically unlike the mental states I experience when I'm not playing.

B. Overview of the Thesis and Vocabulary:

The paper you are about to read examines religious technologies and the role of the human body in ritual practice. I will argue that ritual technologies like chanting, drumming, mantra recitation, and prayer, all utilize repetitive sounds to help induce a wide variety of states of consciousness that correspond to the tempo or rate of the repetition. The specifics of how this happens in the brain have only been cursorily articulated in most of the religious studies and anthropological literature. I believe this is because there has been little systematic lab work done to tease out what exactly the role of sound in ritual is, and how it relates to various mental states, and so there isn't much to report on. I believe that this hasn't been addressed because of a blatant oversight on the part of researchers. It's not that they're not interested in this question—in fact, there has been a lot of speculation and theories built around an electro-magnetic model of the brain in which brainwaves are influenced by sound stimuli in such a way that altered states result from this interaction. The oversight is that this brainwave stimulation hypothesis, which I will call the "auditory driving hypothesis," has not been proven. But it has been referenced so many times by various authors that I think the question of whether it is still theoretical or not has slipped through the cracks, and no one has noticed that a coherent argument on the matter is badly needed.

Secondly, and more generally, this paper will stand as a synthesis of what the psychologists and neuroscientists in the West know about the brain and what the religious studies and anthropological accounts of trance phenomena can offer on the topic. I will bring contemporary neuroscience into dialogue with existing conceptions of trance and its relationship with music, in a way that will be interesting and informative to religious

studies academics and various non-academics, as well as neuroscientists interested in states of consciousness and the view of the brain that the meditative traditions of the world can offer.

In order to do this, I will intersperse vocabulary that is common to anthropologists and religious studies academics who describe meditation with the words of western psychologists. I will define any terms that I use and try to stay away from any unnecessary jargon.

In particular, even though the term "altered states of consciousness (ASCs)" is widely recognizable, it suggests that people in these states are somehow less than conscious, or that these states should be dissociated from other conscious activity. Though I agree that they are very different, a better term seems to be Stanislav Grof's "non-ordinary states of consciousness (NOSCs)" which connotes more of the idea of a continuum and interlacing of regular states with exaggerated aspects of those states, which sometimes leads to experiences that are very extraordinary. I'll use the term NOSC to refer to meditations and trance phenomena of many varieties. As my argument unfolds, I'll explain any distinctions between these phenomena that are relevant to the discussion.

Another important term in this paper is "entrainment." Entrainment is defined as "a synchronization of two or more rhythmic cycles" and was first discovered by Dutch scientist Christian Huygens in 1665.[2] One of the experiments that led to this discovery was when Huygens set up a room full of pendulum clocks and got them all started one at a time. He found that when he came back to the room a day later, the sway of their pendulums had all synchronized. From this, he extrapolated that entrainment represented

[2]Strong, Jeff. "Rhythmic Entrainment Intervention: A Theoretical Perspective." *Open Ear Journal*, 2/98.

a ubiquitous natural phenomenon that had to do with the conservation of energy during the interaction of closely related rhythmic cycles.

This principle posits that any two vibrating bodies will entrain if exposed to each other for long enough. It's true of clocks and electric driers sitting in close proximity to each other; it also describes the way musicians manage to play in time together in groups, the way women's menstrual cycles fall into synch when they live with one another, and the way our body systems interact. Within our bodies, our various rhythmic systems never fight each other—they always fall into synchronized rhythms—and a lack of synchronization, like in the case of a bad heart valve that is not quite timed to the flow of blood, leads to sickness. It also seems to be the case that these body systems entrain, become synchronized, to the environment, to its oscillating features. There is overwhelming evidence that circadian rhythms keep us entrained to the rhythms of the earth relative to the sun, and that various systems within our bodies entrain to repetitive stimulation. Other examples are the way that two people walking next to one another will fall into step with each other, or the way that people clapping in a full room will synchronize their claps given enough time.[3] I will discuss this phenomenon extensively in chapter 4, focusing specifically on the way that brainwave rhythms seem to entrain to rhythmic stimuli in the environment.

C. Thesis:

[3] Z. Néda, E. Ravasz, Y. Brechet, T. Vicsek, and A.-L. Barabási. "Self-organizing process: The sound of many hands clapping." *Nature*, 403, 849-850 (2000).

This paper will attempt to prove that repetitive audible sonic rhythms can induce specific NOSCs in listeners depending on the tempo at which they are played or sung at. This phenomenon, by which a person's bodily functions, such as their heartbeat, breathing and/or brainwaves, become synchronized to an external auditory rhythm, is referred to as auditory driving, or sonic entrainment. If the rhythm comes from flashing lights, it would be called photic entrainment, and from massage, tactile entrainment. Many studies on sleep and meditation, among other areas, have verified the connection between the rate of brainwaves in human subjects and their states of consciousness. Therefore, by demonstrating that it is possible to alter the frequency of a person's brainwaves by exposing them to a sound stimulus, I will be demonstrating that it is possible to alter a person's state of consciousness with a sound stimulus. In addition to the research I will present supporting this thesis, I conducted an experiment in which I studied the mental/physical effects of rhythmic beats on human test subjects at the Stanford Sleep Lab. I used sonic beats in the beta (13-30Hz), alpha (8-13Hz), and theta (4-8Hz) ranges to test this hypothesis while I monitored the subjects' brainwaves using an electroencephalograph (EEG) machine. I hoped to see the same effects that Andrew Neher, scientist and ethnomusicologist, observed in the auditory driving study he performed in 1961.

D. Outline:

This paper will begin with an overview of the oscillating neural network model of the brain, the neuroscientific framework that seems the most relevant to an extensive discussion of brainwave phenomena. I'll move from there to discuss various patterns of

brainwaves and their established links to a variety of states of consciousness. After that, I'll briefly flesh out both of these prior discussions with a review of biofeedback, a technique that lends support to the neural network paradigm and suggests the intimate links between brainwaves and psychological states like depression, anxiety, obsessive compulsion, and attention deficit disorder (ADD). Once this framework is established, I'll review some of the historical and contemporary anthropological work and hypotheses on auditory driving. From there I'll present the existing lab evidence that auditory driving works in the brainwave manner that many contemporary anthropologists believe it does, and then lend additional support to that argument by reviewing the evidence that other forms of auditory and photic entrainment occur, producing exactly the same subjective and phenomenological states of mind as classical auditory driving. After that, I'll present an argument that chanting utilizes brainwave entrainment, often in tempo-specific ways. I'll add to that discussion with a review of Shamanic drumming and other examples of auditory entrainment. I will argue that each of these ritual forms of entrainment seem to exploit tempos that generate brainwaves that correlate with the subjective experiences and concomitant states of consciousness that are sought after in various ritual contexts. Lastly, I'll review the study that I conducted in the Stanford Sleep Lab to try to further validate this argument, and report my encouraging preliminary results.

In addition to providing a cogent argument for brainwave entrainment, this discussion will hopefully lead to a clearer understanding of the full impact ritual music has on peoples' consciousness while playing or listening to it. Many of the connections that will be made here will also be relevant to understanding more about what happens

during intense listening to many other kinds of music, but I'm only going to make the connections explicit using ritual music examples.

Chapter 2: Overview of the EEG and Neural Network Models of the Brain and Consciousness

A. Overview of the Neural Network Model:

This chapter will discuss and review some of the neuroscientific research from the past 50 years that has been devoted to the study of brainwave electro-magnetic phenomena in human beings. This section is here to explain and argue for the links between various patterns of brainwaves and various states of consciousness. This linkage is necessary to understand the next discussion on the effects that various forms of stimulation have on one's brainwaves. Overall, these findings support the oscillating neural-network model of the brain, which I believe can be used to support my thesis on sonic driving. This model is relatively new to neuroscience and is not the most popular way to think about the brain at this time. However, the reading I've done makes this model seem tremendously compelling to me given its ability to directly interface with many of the questions on the nature of consciousness that I have pursued as a Religious Studies major. Hopefully, this portion of my thesis will lead the reader to that same impression.

Brainwaves have been studied since the 1930s when Hans Berger invented the electroencephalograph (EEG) in order record the trace electrical activity at the surface of the human skull. This electrical activity is present throughout the body and is a byproduct of the activity within every living cell.[4] An EEG is recorded using electrodes attached to one's scalp, or via the implantation of needle-like electrodes directly into various portions of the brain. The EEG recording, called an electroencephalogram,

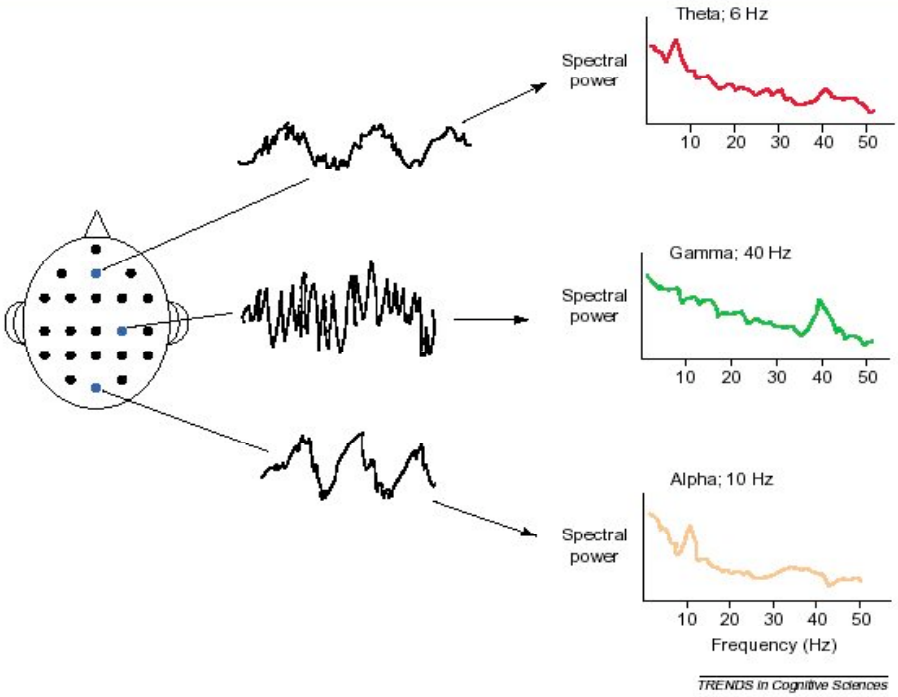
[4] Waechter, Randall. "Qi and Bioelectromagnetic Energy." A Minor Area Paper, Submitted to the Faculty of Graduate Studies, In partial fulfillment of The Doctorate of Philosophy Degree, York University, Draft June 2002. pg. 6.

displays the electrical activity as waves, in the past drawn onto paper like a seismograph, and now digitized in most labs. This wave-like property of the electrical signals led to the term "brainwaves." The frequencies of these waves fall into 5 ranges that are commonly studied: gamma (30-70Hz), beta (13-30Hz), alpha (8-13Hz), theta (4-8Hz), and delta (1-4Hz).[5] Although any of these frequencies can occur at any electrode site, alpha waves are often recorded at posterior sites, theta waves at frontal sites, and gamma waves over sensory cortices.[6] Each of these wave patterns have been correlated with various conscious phenomena through studies of sleep, attention, meditation, hypnosis, music, and other areas. In the following pages I will review some of the literature on each of these fields in order to clarify the connections between conscious experience and brainwave responses.

The waves or oscillations depicted by an EEG or MEG (magnetoencephalograph, a newer and less-frequently used technique for capturing brainwave activity) reflect the activity of cortical neuron groups, neurons located in the grey-matter (cortex) of the brain that overlays the white-matter. The grey-matter is made up of the nerve cell bodies and the white-matter of the neuron fibers connecting each of the nerve cell bodies to various places in the brain.[7] The amplitude of the waves observed on an EEG, or the "power" observed at certain frequency bandwidths (gamma, beta, alpha, etc.) depends on the number of neurons within a given network.[8] An additional measure called "spectral power analysis" measures to what extent the EEG-generating neurons are oscillating synchronously at various frequencies. In other words, spectral power refers to what

[5] Rechtschaffen, A. and Kales, A. (Eds.) "A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects." BIS/BRI, UCLA, Los Angeles, 1968.
[6] Ward, LM. "Synchronous neural oscillations and cognitive processes." *Trends Cogn Sci*. 2003 Dec;7(12):553-559.
[7] http://www.medterms.com/script/main/art.asp?articlekey=6018 4/25/05.
[8] Ward, 2003.

extent a region of your brain, made up of several rhythmic neural networks, is pulsing in time at a given frequency, as a coherent unit. This is why these networks are described as "oscillating," because of the way they synchronize and fire in rhythm, as a group. It has been widely suggested that the synchronous pulsing of neural networks is a means of communication between them, and when this is observed it means that the synchronous brain areas are working together.[9] Examples of networks in the cortex would include the frontal lobes, the auditory cortexes, the occipital lobes, etc. Each area pulses at different tempos depending on what is happening in consciousness at the time. I will be explicit in my discussion of brainwaves as either occurring locally, in one area of the brain, or globally, as in an "alpha-state" in which alpha waves are found in multiple areas.



10

[9]Varela, F. *et al*. (2001) "The brainweb: phase synchronization and largescale integration." *Nat. Rev. Neurosci.* 2, 229–239.
[10]Ward 2003, pg. 555. Spectral power examples at 6, 40, and 10Hz measured a various electrode sites.

Laurence Ward, a professor in the psychology department at the University of British Colombia, has written extensively on oscillating neural networks. He clearly articulates why the neural network model of cognition is valuable even amid the current trend in neuroscience which is heavily biased towards the use of functional magnetic resonance imaging (fMRI), which unlike EEG and MEG, tracks blood flow through the brain. The picture of blood flow leads to information about the workings of specific brain areas, but does not reflect the real-time interactions between them. The electro-magnetic pictures that are available from EEG and MEG shows how the brain works in real-time as an interconnected whole. This electro-magnetic reverberation model of the brain is gaining support from a variety of sources.[11] Ward writes:

> A popular way to think about the relationship between brain dynamics and cognitive dynamics is to describe the sequence of brain areas that 'light up' during the various stages in the performance of a cognitive task, like the sequence of bumpers hit by a pinball shot from its spring.[12] This approach is limited, however, because it cannot describe in any detail what is going on in those lit-up areas. Moreover, it doesn't seem to be able to cope fully with the emerging view of brain processes as reverberations of reentrant activity in a complex neural network.[13]

As I began learning about this, the oscillating neural network model seemed extremely intuitive to me, given its thoroughly rhythmic and harmonic structure.

One of the leading theories right now comes from Edelman and Tononi who suggest that the neural basis for consciousness comes from what they call a "dynamic

---

[11]-Lamme, V.A.F. and Roelfsema, P.R. (2000) "The distinct modes of vision offered by feedforward and recurrent processing." *Trends Neurosci.* 23, 571–579
-Varela, 2001.
-Basar, E. *et al*. (2000) "Brain oscillations in perception and memory." *Int. J. Psychophysiol*. 35, 95–124
-Nunez, P.G. *et al*. (2000) "Toward a quantitative description of largescale neocortical dynamic function and EEG." *Behav. Brain Sci*. 23, 371–437
-Levine, D.S., et al. eds (1999) "Oscillations in Neural Systems," *Erlbaum*
[12]-Posner, M.I. and Raichle, M.E. (1994) "Images of Mind," *Scientific American Library*
-Glanz, J. (1998) "Magnetic brain imaging traces a stairway to memory." *Science* 280, 37–38
-Zeineh, M.M. et al. (2003) "Dynamics of the hippocampus during encoding and retrieval of face-name pairs." *Science* 299, 577–580
[13] Ward 2003, pg. 553.

core" of synchronous firing occurring globally, across many brain areas.[14] The basic idea is that when an individual is being stimulated, visually, in the example they give, there is synchronous firing between the neurons in the portion of their brain that is handling the stimulation.[15] The synchronous firing of the neurons in this area causes that area to act like one big oscillator. The experiment they set up used a binocular rivalry task, so they could present images to each eye separately. When the subject saw an image, and that image was in consciousness, Edelman and Tononi saw pulsations of neurons at various non-sensory sites that were firing synchronously with the neurons in the sensory sites. When they presented an image to the other eye, while the subject's attention was on the image in their opposite eye, this widespread non-sensory site synchrony was not observed. This led to the conclusion that the global firing they observed is only present when a stimulus is in consciousness, and that other sensory-evoked firing, occurring in particular brain areas, does not produce a conscious experience of that stimulus until it has been integrated, through global brain synchrony, into the "dynamic core."

This is another argument for the usefulness of EEG data vs. fMRI data. This kind of synchrony cannot be observed on an fMRI. The theory that observed global brain synchrony between sensory and non-sensory areas means that a subject has a stimulus in conscious awareness began in the early 1990s with Crick and Koch and their studies of visual awareness.[16] Ward explains that since then there have been several important studies correlating conscious awareness of a stimulus with neural activity at various frequencies, including the one mentioned in the previous paragraph. He goes on: "In one

[14] -Tononi, G. and Edelman, G.M. (1998) "Consciousness and complexity." *Science* 282, 1846–1851
-Edelman, G.M. and Tononi, G. (2000) "A Universe of Consciousness," *Basic Books*
[15] -Tononi, G. et al. (1998) "Investigating neural correlates of conscious perception by frequency-tagged neuromagnetic responses." *Proc. Natl. Acad. Sci. U. S. A.* 95, 3198–3203
[16]Crick, F. and Koch, C. (1990) "Some reflections on visual awareness." *Cold Spring Harb. Symp. Quant. Biol.* 55, 953–962

of these, the EEG was recorded while subjects viewed an ambiguous visual stimulus that could be perceived as either a face or as a meaningless shape.[17] When subjects reported seeing a face, phase synchronization at the gamma frequency occurred across widely-separated brain areas; this synchronization did not appear when a meaningless pattern was reported."[18]

One new scope of understanding that may emerge from this theory of mind could be knowledge about the nature and cause of mental illness, a topic we will return to later in this chapter during the discussion of biofeedback and deep brain stimulation techniques. Francisco Varela and his team of neuroscientists working on the dynamics of neural networks writes, in a study[19] published in *Nature* in 2001:

> If large-scale synchrony is the basis for normal brain functioning, then synchrony disruption should cause functional abnormalities.[20] In epilepsy, the local intrinsic frequencies become enslaved to a pacemaker and give rise to slow, uniform oscillations that arise over minutes.[21] In Parkinson's disease, tremor has been proposed to arise from the spread of abnormal coupling patterns between the representations of the limb muscles in basal ganglia.[22] It has also been proposed that a disruption of synchrony is related to the fragmented cognitive experience of patients with schizophrenia.[23]

A main aspect of the thesis I am putting forth about ritual music and the effect that it has on your brain is that it seems to help synchronize many areas at once.

---

[17]Rodriguez, E. *et al*. (1999) "Perception's shadow: long-distance synchronization of human brain activity." *Nature* 397, 430–433
[18] Ward, 2003. Pg. 558.
[19]Varela, 2001. Pg. 236.
[20]-Mackey, M. C. & Glass, L. (1977) "Oscillation and chaos in physiological control systems." *Science* 197, 287–289
-Llinas, R. R., Ribary, U., Jeanmonod, D., Kronberg, E. & Mitra, P. P. (1999) "Thalamocortical dysrhythmia: a neurological and neuropsychiatric syndrome characterized by magnetoencephalography." *Proc. Natl Acad. Sci. USA* 96, 15222–15227
[21]-Martinerie, J. *et al*. (1998) "Epileptic seizures can be anticipated by nonlinear analysis." *Nature Med*. 4, 1173–1176
-Le Van Quyen, M. *et al*. (2001) "Anticipation of epileptic seizures from standard EEG recordings." *Lancet* 357, 183–188
[22]Hurtado, J. M., Lachaux, J. P., Beckley, D. J., Gray, C. M. & Sigvardt, K. A. (2000) "Inter- and intralimb oscillator coupling in parkinsonian tremor." *Mov. Disord*. 15, 683–691
[23]-Hoffman, R. E. & McGlashan, T. H. (1993) "Parallel distributed processing and the emergence of schizophrenic symptoms." *Schizophr. Bull*. 19, 119–140
-Tononi, G. & Edelman, G. M. (2000) "Schizophrenia and the mechanisms of conscious integration." *Brain Res. Rev*. 31, 391–400

This is echoed by the success that sonic therapy has already had treating a variety of disorders. I'll return to this later in the thesis. Varela's paper ends:

> The studies that we have reviewed support the idea that phase synchrony is essential for large-scale integration [of various brain areas]. The evidence is well grounded in single-cell recordings and [implanted electrode] studies in animals, and also in evidence from humans using more global measurements such as EEG and MEG. Similar characteristics seem to emerge at all levels of resolution. *We seem to be scratching the tip of a large new area of brain understanding that could become a dominant area of research in neuroscience* [my emphasis].[24]

Now that the general principles behind the neural network model have been clarified, and a little bit of information about how those principles came about has been offered, I am going to discuss each of the different frequency bands of brainwaves that are relevant to the forms of brainwave stimulation I will discuss later on. This section will attempt to show the linkages between observed brainwave patterns and the different conscious functions and experiences that correlate with their presence in the brain.

B. Gamma Waves:

The gamma frequency band (30-70Hz) is the highest frequency band we will discuss. A variety of studies have associated this range with processing of various attended stimuli (visual, auditory, tactile)[25] and the grouping of the various features of a given stimulus, particularly visual, into a coherent whole.[26] One of the visual studies just referenced highlights the connection between attention and the role of gamma waves. It demonstrated that when desynchronization of gamma waves occurred while subjects

---

[24]Varela, 2001. Pg. 236.

[25]-Keil, A. et al. (2001) "Functional correlates of macroscopic high frequency brain activity in the human visual system." *Neurosci. Biobehav. Rev*. 25, 527–534

-Singer W. "Synchronization of cortical activity and its putative role in information processing and learning." *Annu Rev Physiol.* 1993;55:349-374.

-Traub RD, Whittington MA, Stanford IM, Jerfferys JGR. "A mechanism for generation of long-range synchronous fast oscillations in the cortex." *Nature*. 1996;383:621-624.

[26]Tallon-Baudry C, Bertrand O, Peronnet F et al. (1998) *J Neurosci* 18, 4244±4254

attended to visual stimuli, according to their reports, the subjects didn't see the stimuli that were presented.[27] As might be expected, gamma waves disappear during deep sleep induced by anesthesia[28] but are enhanced during the return to wakefulness.[29] In addition, gamma waves have a role in memory processing. The rate of the waves seems to correlate with the speed at which a subject can recall memories; the faster the waves, the faster the recollection.[30]

Gamma waves have also been the subject of recent studies on meditation. One of these studies demonstrated that long-term Buddhist meditation practitioners "self-induced high-amplitude gamma-band oscillations and phase-synchrony" during an unconditional loving-kindness and compassion meditation.[31] This meditation induces a non-referential state of compassion towards all sentient beings. The gamma oscillations differed significantly from controls both during and before the meditation began. Interestingly, a similarly strong presence of gamma waves throughout the cortex, relative to controls, was observed in the last few years in at least two different studies of musicians listening to music compared to non-musicians listening to music.[32]

---

[27]Fell, J. et al. (2002) "Suppression of EEG gamma activity may cause the attentional blink." *Conscious. Cogn.* 11, 114–122

[28]John, E. R. *et al.* "Invariant reversible QEEG effects of anesthetics." *Conscious Cogn.* (in the press).

[29]-Munk, M. H., Roelfsema, P. R., Konig, P., Engel, A. K. & Singer, W. "Role of reticular activation in the modulation of intracortical synchronization." *Science* 272, 271–274 (1996).
-Herculano-Houzel, S., Munk, M. H., Neuenschwander, S. & Singer, W. "Precisely synchronized oscillatory firing patterns require electroencephalographic activation." *J. Neurosci.* 19, 3992–4010 (1999).

[30]27 Burle, B. and Bonnet, M. (2000) "High-speed memory scanning: a behavioral argument for a serial oscillatory model." *Brain Res. Cogn. Brain Res.* 9, 327–337

[31]Lutz A. et al. "Long-term meditators self-induce high-amplitude gamma synchrony during mental practice." *Proc Natl Acad Sci U S A.* 2004 Nov 16;101(46):16369-73.

[32]-Bhattacharya J. et al. "EEG gamma-band phase synchronization between posterior and frontal cortex during mental rotation in humans." *Neurosci Lett.* 2001 Sep 21;311(1):29-32.
- Bhattacharya J. et al. "Musicians and the gamma band: a secret affair?" *Neuroreport.* 2001 Feb 12;12(2):371-4.
- Bhattacharya J. et al. "Enhanced phase synchrony in the electroencephalograph gamma band for musicians while listening to music." *Phys Rev E Stat Nonlin Soft Matter Phys.* 2001 Jul;64(1 Pt 1):012902.

C. Beta Waves:

The next slowest frequency band is beta (13-30Hz). A beta state, in the sense of beta waves oscillating throughout the cortex, only occurs during wakefulness.[33] A point of clarification is that there is no such thing as a "gamma state." Gamma waves largely play a supporting – though integral- role in the brain. From an EEG point of view, they will be present mostly while a subject is awake, but they will always be supported by other waves in the beta, alpha, theta, or delta ranges. In general, beta-states are associated with strong, excited emotions such as fear, rage, or anxiety, as well as with alert attentiveness, selective attention, concentration, or anticipation.[34] Other studies have correlated beta waves with alert behavior, concentrated mental activity such as solving math problems, anxiety, and apprehension.[35]

When beta waves have been observed during meditation, they tend to only occur in very experienced practitioners and generally only during moments of ecstasy or intense concentration. Buddhist, Hindu, and other meditators have been studied fairly extensively along these lines.[36] On a completely different front, the newly popular

---

[33]Rechtschaffen, 1968.

[34] Lindsley D. "Psychological phenomena and the electroencephalogram." *Electroencephalogr Clin Neurophysiol Suppl.* 1952 Nov;4(4):443-56.

[35] Brown, B. B. (1977) "Stress and the Art of Biofeedback." New York: Bantam Books.

[36]-West, M.A. "Meditation and the EEG."*Psychological Medicine* 10, no. 2 (1980a): 369-375.
-West, M.A. "Physiological Effects of Meditation: A Longitudinal Study."*British Journal of Social and Clinical Psychology* 18, no. 2 (1979a): 219-226.
-Corby, J.C., W.T. Roth, V.P. Zarcone, et al. "Psychophysiological Correlates of the Practice of Tantric Yoga Meditation." *Archives of General Psychiatry* 35, no. 5 (1978): 571-577.
-Surwillo, W.W., and D.P. Hobson. "Brain Electrical Activity during Prayer." *Psychological Reports* 43, no. 1 (1978): 135-143.
-Fenwick, P., S. Donaldson, L. Gillis, et al. "Metabolic and EEG Changes during Transcendental Meditation: An Explanation." *Biological Psychology* 5, no. 2 (1977): 101-118.
-Banquet, J.P. "Spectral Analysis of the EEG in Meditation." *Electroencephalography and Clinical Neurophysiology* 35 (1973): 143-151.
-Kasamatsu, A., and T. Hirai. "Science of Zazen."*Psychologia* 6 (1963): 86-91.
-Kasamatsu, A., and T. Hirai. "An EEG Study on the Zen Meditation (Zazen)."*Folia Psychiatrica et Neurologia Japonica* 20, no. 4 (1966): 315-336.
-Das, N., and H. Gastaut. "Variations in the Electrical Activity of the Brain, Heart, and Skeletal Muscles during Yogic Meditation and Trance."*Electroencephalography and Clinical Neurophysiology, supplement* no. 6 (1955): 211-219.

medications Ritalin and Adderall, both of which are used to induce concentration and alertness, produce a beta state in most subjects.[37]

D. Alpha Waves:

Alpha waves (8-13Hz) have been studied extensively in work on attention and meditation. In general, they seem to suppress cortical activity in areas of the brain that are not being used to focus on stimuli. In other words, if a visual stimulus is presented to a subject, areas of brain devoted to tactile sensation and auditory sensation will show enhanced alpha wave activity.[38] In memory scanning tasks, where subjects attempt to memorize lists of words, it has been shown that as the task gets more difficult, alpha power will increase in areas relevant to suppressing distractions.[39] During mental imagery tasks, it has also been shown that alpha power increases in areas of the brain that detect the subject's outer environment and that as the task gets harder, alpha power will increase in those same areas.[40]

Alpha waves also seem to be relevant in cases where a subject is asked to anticipate the presentation of a particular stimulus. Examples of this come from two recent studies in which alpha power increased over the visual cortex to a greater degree when a cue for an auditory stimulus was given than a cue for a visual stimulus.[41] This

---

[37] -Loo SK et al. "EEG correlates of methylphenidate response among children with ADHD: a preliminary report." *Biol Psychiatry*. 1999 Jun 15;45(12):1657-60.
-Herrmann WM, Kubicki S. "The use of electrophysiological techniques to project typical psychotropic drug effects: some examples." EEG EMG Z *Elektroenzephalogr Elektromyogr Verwandte Geb*. 1981 Mar;12(1):21-32.
-Clarke AR et al. "Effects of stimulant medications on the EEG of children with attention-deficit/hyperactivity disorder." *Psychopharmacology (Berl)*. 2002 Nov;164(3):277-84.
[38] Ward, 2003.
[39]Jensen, O. et al. (2002) "Oscillations in the alpha band (9–12 Hz) increase with memory load during retention in a short-term memory task." *Cereb. Cortex* 12, 877–882
[40]Cooper, N. et al. (2003) "Paradox lost? Exploring the role of alpha oscillations during externally vs. internally directed attention and the implications for idling and inhibition hypotheses." *Int. J. Psychophysiol*. 47, 65–74
[41]-Foxe, J.J. et al. (1998) "Parieto-occipital ,10 Hz activity state of visual attention mechanisms." *Neuroreport* 9, 3929–3933
-Fu, K-M.G. et al. (2001) "Attention-dependent suppression of distractor visual input can be cross-modally cued as indexed by anticipatory perieto-occipital alpha-band oscillations." *Brain Res. Cogn. Brain Res.*12, 145–152

same effect has been observed in visual tasks where changes in alpha power will occur precisely over cortical areas representing distractions in the visual field.[42]

Alpha states, in which alpha waves are observed throughout the cortex, are generally associated with relaxed wakefulness, and creative thought where attention may wander and free association is favored.[43] Alpha states are also correlated with a generally tranquil, pleasant, almost floating feeling.[44] These sorts of characterizations of alpha states mostly reflect tasks where the subject is sitting or lying with their eyes closed and reporting these effects. Alpha waves appear immediately when subjects close their eyes and spread throughout the cortex. This seems to be an integral part of the relaxation process before sleep.[45]

The alpha frequency band has been studied extensively in meditations of various kinds.[46] One study on Sahaja Yoga, a type of mediation characterized by internalized

---

[42]Worden, M.S. et al. (2000) Anitcipatory biasing of visuospatial attention indexed by retinotopically specific a-band encephalography increases over occipital cortex. J. Neurosci. 20, RC63

[43]Lindsley D. Psychological phenomena and the electroencephalogram. Electroencephalogr Clin Neurophysiol Suppl. 1952 Nov;4(4):443-56.

[44]Brown, B. B. (1977). Stress and the Art of Biofeedback. New York: Bantam Books.

[45]Rechtschaffen, A. and Kales, A. (Eds.) A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects. BIS/BRI, UCLA, Los Angeles, 1968.

[46] -Delmonte, M.M "Physiological Responses during Meditation and Rest." *Biofeedback and Self-Regulation* 9, no. 2 (1984f): 181-200.

-Stigsby, B., J.C. Rodenburg, and H.B. Moth. "Electroencephalographic Findings during Mantra Meditation (Transcendental Meditation): A Controlled, Quantitative Study of Experienced Meditators."
Electroencephalography and Clinical Neurophysiology 51, no 4 (1981): 434-442.

-Lehrer, P.M., S. Schoicket, P. Carrington, et al. "Psychophysiological and Cognitive Responses to Stressful Stimuli in Subjects Practicing Progressive Relaxation and Clinically Standardized Meditation."
Behavior Research and Therapy 18, no. 4 (1980): 293-303.

-Wachsmuth, D., T. Dolce, and K. Offenloch."Computerized Analysis of the EEG during Transcendental Meditation and Sleep."
Electroencephalography and Clinical Neurophysiology 48, no. 3 (1980): 39.

-West, M.A. "Meditation and the EEG." *Psychological Medicine* 10, no. 2 (1980a): 369-375.

-Dostalek, C., J. Faber, E. Krasa, et al. "Yoga Meditation Effect on the EEG and EMG Activity." *Activitas Nervos Superior (Praha)* 21, no. 1 (1979): 41.

-Corby, J.C., W.T. Roth, V.P. Zarcone, et al. "Psychophysiological Correlates of the Practice of Tantric Yoga Meditation."
Archives of General Psychiatry 35, no. 5 (1978): 571-577.

-Elson, B.D., P. Hauri, and D. Cunis. "Physiological Changes in Yoga Meditation." *Psychophysiology* 14, no. 1 (1977): 55-57.

-Kasamatsu, A., T. Okuma, and S. Takenaka. "The EEG of 'Zen' and 'Yoga' Practitioners."*EEG Clinical Neurophysiology, supplement* 9 (1957): 51-52.

-Woolfolk, R.L. "Psychophysiological Correlates of Meditation."*Archives of General Psychiatry* 32, no. 10 (1975): 1326-1333.

-Banquet, J.P. "EEG and Meditation."*Electroencephalography and Clinical Neurophysiology* 33 (1972): 454.

-Akishige, Y., ed. *Psychological Studies on Zen*. Tokyo: Zen Institute of the Komazawa University, 1970.

-Kasamatsu, A., and T. Hirai. "An EEG Study on the Zen Meditation (Zazen)." *Folia Psychiatrica et Neurologia Japonica* 20, no. 4 (1966): 315-336.

-Kasamatsu, A., and T. Hirai. "An EEG Study on the Zen Meditation (Zazen)."*Psychologia 12, nos. 3-* 4 (1969a): 205-225.

-Hirai, T. "Electroencephalographic Study on the Zen Meditation (Zazen): EEG Changes during the Concentrated Relaxation."

attention and positive emotion, showed increases in alpha waves that were associated with suppressed sensitivity to external stimuli.[47] Kasamatsu and Hirai observed alpha waves in Zen meditators[48], and studies on transcendental meditation have offered similar results.(see footnote 46) In many of these studies alpha wave power is higher than non-mediators both during and after meditation. Also interestingly, cannabis use has been linked extensively to elevated alpha waves both during the active effects of the drug and afterwards.[49] This is interesting given the drug's effects of inducing states of increased concentration and focus that tend to drift from object to object.[50] It is likely that in the case of meditators, they are balancing beta waves and alpha waves—the beta waves keep their meditation linear, in the sense that they keep their focus on the same object of meditation consistently, as the alpha waves in their brains let them focus in intensely on that object. The difference in phenomenology between meditation experiences and cannabis experiences, at least in part, may have very much to do with a lack of beta wave production in the initial stages of cannabis use. As use continues, users find that they can focus on one object for longer and longer. This process of learning to focus on one thing may reflect the users' increased production of beta waves.

Psychiatrica et Neurologia Japanica 62 (1960): 76-105.
-Hirai, T., S. Izawa, and E. Koga. "EEG and Zen Buddhism: EEG Changes in the Course of Meditation." *Electroencephalography and Clinical Neurophysiology, supplement no. 18* (1959): 52-53.
[47]Aftanas, L.I. et al. "Non-linear dynamic complexity of the human EEG during evoked emotions", *Int. J. Psychophysiol.,* 28 (1998) 63–67.
[48] Kasamatsu, A., and T. Hirai. "Science of Zazen."*Psychologia* 6 (1963): 86-91.
[49]-Struve FA et al. "Acute marihuana (THC) exposure produces a "transient" topographic quantitative EEG profile identical to the "persistent" profile seen in chronic heavy users." *Clin Electroencephalogr*. 2003 Apr;34(2):75-83.
-Struve FA et al. "Topographic quantitative EEG sequelae of chronic marihuana use: a replication using medically and psychiatrically screened normal subjects." *Drug Alcohol Depend*. 1999 Oct 1;56(3):167-79.
-Patrick G et al. "Reduced P50 auditory gating response in psychiatrically normal chronic marihuana users: a pilot study." *Biol Psychiatry*. 1999 May 15;45(10):1307-12.
- Struve FA, et al."Possible EEG sequelae of very long duration marihuana use: pilot findings from topographic quantitative EEG analyses of subjects with 15 to 24 years of cumulative daily exposure to THC." *Clin Electroencephalogr*. 1998 Jan;29(1):31-6.
-Lukas SE et al. "Electroencephalographic correlates of marihuana-induced euphoria." *Drug Alcohol Depend.* 1995 Feb;37(2):131-40.
- Struve FA et al. "Persistent topographic quantitative EEG sequelae of chronic marihuana use: a replication study and initial discriminant function analysis. *Clin Electroencephalogr*. 1994 Apr;25(2):63-75.
[50]Klonoff H. "The phenomenology of the marihuana user." *Can J Public Health*. 1973 Nov-Dec;64(6):552-61

E. Theta Waves:

Theta waves (4-7Hz) have been linked with many different phenomena in the brain. Studies on memory, emotion, plasticity, sleep, meditation, and hypnosis all draw connections between theta waves and conscious phenomena. On the localized level, as opposed to the sense of the whole-brain theta-state, theta waves seem to be involved in short-term memory. A theory proposed by Lisman and Idiart[51] suggests that short-term memories are constantly refreshed in order to retain their salience in the brain while they are being accessed. They hypothesize that the individual memories are refreshed at the gamma rate while the whole refresh cycle pulses at a theta rate. They suggest that this may be why an average of 7 items can be held in short term memory by most individuals[52]—per each 6Hz theta oscillation the 40Hz gamma oscillation can cycle an average of 7 times.

Many studies have confirmed the theta frequency's role in memory-related tasks and the encoding and retrieval of long-term memories.[53] Increases in theta have also been observed during emotional arousal.[54] Both of these phenomena are related to neural plasticity that is induced via theta oscillations in the hippocampus.[55] These findings provide a neural-network-model-based argument for the statement that emotional arousal leads to readiness in the human brain to encode new memories. This seems particularly interesting given the way these findings may relate to the observations of the whole-brain

---

[51]Lisman, J.E. and Idiart, M.A.P. (1995) "Storage of 7 ^ 2 short-term memories in oscillatory subcycles." *Science* 267, 1512–1515

[52]Miller, G.A. (1956) "The magical number seven plus or minus two: some limits on our capacity for processing information." *Psychol. Rev.* 63, 81–97.

[53]-Pare, D. *et al.* (2002) "Amygdala oscillations and the consolidation of emotional memories." *Trends Cogn. Sci.* 6, 306–314

-Basar, E. et al. (2000) "Brain oscillations in perception and memory." *Int.J. Psychophysiol.* 35, 95–124

-Klimesch, W. (1999) "EEG alpha and theta oscillations reflect cognitive and memory performance: a review and analysis." *Brain Res. Brain Res. Rev.* 29, 169–195

[54]-Pelletier JG *et al.* "Lasting increases in basolateral amygdala activity after emotional arousal: Implications for facilitated consolidation of emotional memories." *Learn Mem.* 2005 Mar-Apr;12(2):96-102.

-Paré, D. and Gaudreau, H. "Projection cells and interneurons of the lateral and basolateral amygdala: Distinct firing patterns and differential relation to theta and delta rhythms in conscious cats." 1996. *J. Neurosci.* 16:3334

[55]Pelletier JG, 2005.

theta-states of the hypnogogic state, certain types of meditation, especially visualization meditations, and hypnosis—all of which involve intense subjectivity, in the sense that one can come back with an extremely vivid memory and lasting impressions of the experience.

The theta-state is described by sleep researchers as stage 1 sleep.[56] This is considered a sleep stage because subjects pass out of the alpha-state, in which they still have full awareness of their surroundings, into a theta-state in which subjects lose their sense of lying in bed, and being awake. Subjects can be easily awoken from this stage of sleep, and it has many interesting properties. This state of consciousness is also referred to as a hypnogogic state, or the twilight state. Psychologist Thomas Budzynski explains:

> For a brief time as we lie in bed at night, neither fully awake nor yet asleep, we pass through a twilight mental zone that Arthur Koestler has described as a state of reverie. Many people associate this drowsy stage with hallucinatory images, more fleeting and disjointed than dreams, and compare it to the viewing of a speeded-up, jerky series of photographic slides. A host of artists and scientists have credited the imagery of this twilight state with creative solutions and inspiration for their work.[57]

This phenomenology is supported by psychologist Lindsley in his characterization of the theta-state as a state of drowsiness, with borderline or partial awareness, imagery, reverie and dream-like states of mind.[58] Meditation in this range is extensively documented and seems to share similar properties to the hypnogogic experience in the consistent reports of vivid mental imagery, of peacefulness, drifting, and generally pleasant experiences.[59]

---

[56]Rechtschaffen, A. 1968.
[57]Budzynski, T. H. (1977). "Tuning in on the twilight zone." *Psychology Today*, August.
[58]Lindsley, 1952.
[59]-Fenwick, P., S. Donaldson, L. Gillis, et al. "Metabolic and EEG Changes during Transcendental Meditation: An Explanation."*Biological Psychology* 5, no. 2 (1977): 101-118.
-Elson, B.D., P. Hauri, and D. Cunis."Physiological Changes in Yoga Meditation." *Psychophysiology* 14, no. 1 (1977): 55-57.
-Hirai, 1974.
-Anand, B.K., G.S. Chhina, and B. Singh. "Studies on Shri Ramanand Yogi during His Stay in an Airtight Box." *Indian Journal of Medical Research* 49 (1961b): 82-89.
-Banquet, J.P. "EEG and Meditation." *Electroencephalography and Clinical Neurophysiology* 33 (1972): 454.

The meditations in this category include yogic mediations on the blissful state and relaxation meditation characterized by decreased desire/readiness for action, Transcendental Meditation, and Zen. A theta-state is also observed in subjects under hypnosis.[60] The links between the theta frequency and memory, emotion, and neural plasticity on a localized level can already offer relevant clues to questions on why visualizations of meditators in theta are so vivid, why meditators have such good memories, and why hypnosis can create lasting changes in the brain.

F. Delta Waves:

The last frequency band relevant to this discussion is delta (1-4Hz). Delta waves are consistently observed in deep sleep, also called stages 3 and 4 sleep depending on what percentage of the waves being observed on the EEG are delta waves. It is accepted that as that percentage gets higher, sleep gets deeper.[61] Meditative states associated with the increased presence of delta waves seem to occur mostly in very experienced practitioners, possibly because entering a delta state and maintaining consciousness at the same time is tremendously difficult.[62] One study on religious experiences, where epileptic-like electrical changes in the temporal lobes were the focus, reported that 10 seconds of delta waves in the temporal lobes of a Transcendental meditator correlated

---

-Kjaer et al. "Increased dopamine tone during meditation-induced change of consciousness." *Cog Brain Research* 13 (2002) 255-259.
[60]-Sabourin M.E. *et al*. "EEG correlates of hypnotic susceptibility and hypnotic trance: spectral analysis and coherence." *Int J Psychophysiol*. 1990 Dec;10(2):125-42.
-Stevens L. et al. "Electrophysiological alterations during hypnosis for ego-enhancement: a preliminary investigation." *Am J Clin Hypn*. 2004 Apr;46(4):323-44.
-Williams JD, Gruzelier JH. "Differentiation of hypnosis and relaxation by analysis of narrow band theta and alpha frequencies." Int J Clin Exp Hypn. 2001 Jul;49(3):185-206.
[61]Rechtschaffen, A. 1968.
[62] "Epsilon, Gamma, HyperGamma and Lambda Brainwave Activity and Ecstatic States of Consciousness." Center for Neuroacoustic Research. http://www.neuroacoustic.com/registry/articles/articleepsi.htm. 3/16/04.

with his reports of a peak meditation experience.[63] These observations in the lab setting are extremely rare and additional support for this delta-wave theory of meditative consciousness is currently lacking.

G. Interplay of Alpha and Theta Waves:

Lastly, observations on the interplay of alpha and theta waves can serve to distill some of the information just presented on the links between these frequencies and conscious processes. For instance, alpha power, or the measure of the degree to which alpha waves are active throughout the brain, increases as children mature, while theta and delta power decrease. These changes have been linked with a general increase in cognitive competence that comes with maturation, whereas the reverse change, in which increased theta and delta power are observed, is associated with declining mental abilities in old age.[64] In other words, as you get older, you have more of an ability to focus on particular things because you are better able to suppress distractions, by generating alpha waves in the areas of your brain that need to be suppressed. If that skill, of generating alpha waves on command, has not been learned, attention will not be focused. In addition, the presence of increased theta power in little kids should not be surprising in the sense that they are clearly behaving more like they are in a hypnogogic state than when they get older—their imaginations are more active and they can't focus on any one thing for very long. Their lack of alpha to suppress stimulation could account for their lack of ability to focus, while the increased theta power could account for their greater access to their memories, both to create and reexperience them. Their greater access to

[63]Persinger MA. "Striking EEG profiles from single episodes of glossolalia and transcendental meditation." *Percept Mot Skills*. 1984 Feb;58(1):127-33.
[64]Klimesch, W. (1999) EEG alpha and theta oscillations reflect cognitive and memory performance: a review and analysis. *Brain Res. Rev*. 29, 169–195

their memories would also translate into more potent emotional experiences: given the greater number of associations that they'd constantly make with past experiences, making their present experiences more dynamic, more meaningful, and hence, more emotional. This increased access to memories, with the lack of linearity in their thinking due to the constant stimulation they experience without alpha waves, may have much to do with the perception that little kids are more creative (associative) and imaginative than adults.

Support for this view comes from additional studies on alpha and theta waves: a variety of neurological disadvantages have been associated with high levels of theta and delta power and low alpha power. These observations have come from studies on groups with poor education, reading or writing disabilities, and dementia.[65] Good performance on cognitive memory tasks has also been correlated with individuals with high baseline alpha and low theta power and the event-related decrease of alpha in areas of the brain associated with the performance of the tasks.[66] Finally, in a meditation study comparing relaxation, mindfulness, and concentration states, both concentration and mindfulness showed less overall theta and delta activity and greater alpha and beta activity than relaxation. Additionally, there was both a greater range of frequencies and more theta activity in mindfulness than in concentration.[67] This study seems to lend further support to the notion that theta waves bring greater access to memories than alpha and beta, given the subjective experience of mindfulness meditation which consists of sitting and paying attention to whatever thoughts or memories arise, as opposed to concentration meditation in which all of one's focus is supposed to be directed at one object of concentration.

---

[65]Ibid.
[66]Ibid.
[67]Dunn BR, Hartigan JA, Mikulas WL. "Concentration and mindfulness meditations: unique forms of consciousness?" *Appl Psychophysiol Biofeedback*. 1999 Sep;24(3):147-65.

H. Biofeedback:

This section will describe the technology of biofeedback. I am highlighting this therapeutic modality in order to further support the overall neural network brainwave model, and to demonstrate the ties between various psychological states, like depression, anxiety, and ADD and various brainwave phenomena. The word "biofeedback" was coined in the late 1960s to describe laboratory procedures then being used to train experimental research subjects to alter their own brain activity, blood pressure, heart rate, and other bodily functions that normally are not controlled voluntarily.[68] In an article written for psychotherapy.com, an affiliate of the Division of Communication and Education, National Institute of Mental Health, Bette Runck explains:

> For patients, the biofeedback machine acts as a kind of sixth sense, which allows them to "see" or "hear" activity inside their bodies. One commonly used type of machine, for example, picks up electrical signals in the muscles. It translates these signals into a form that patients can detect: it triggers a flashing light bulb, perhaps, or activates a beeper every time muscles grow more tense. If patients want to relax tense muscles, they try to slow down the flashing or beeping.[69]

Recently, flash bulbs and auditory beeps have been replaced with video game interfaces, featuring highly rendered digital graphics and sounds that react in real-time to physiological data.

Neurofeedback is another type of biofeedback, targeted primarily at mental states rather muscular activity. This approach teaches the patient to recognize his own mental tendencies to do certain things by giving him visual and auditory feedback on the state of

---

[68] "What is Biofeedback?" <http://www.psychotherapy.com/bio.html> 5/30/04.
-Kamiya, J. (1969). "Operant control of the EEG alpha rhythm and some of its reported effects on consciousness." In C. T. Tart (Ed.), Altered states of consciousness (pp. 519-529). Garden City, N. Y.: Anchor Books.
-Brown, B. B. (1970). "Recognition of aspects of consciousness through association with EEG alpha activity represented by a light signal." *Psychophysiology*, 6, 442-452.
[69] Ibid.

his brainwaves. Using an EEG machine, a patient can observe his own brainwaves and learn real-time techniques to change their rhythms, often achieving permanent results over a multi-month long process (40-60 sessions for permanent results is average)[70]. During this time a patient can learn to increase the presence of certain waves and decrease the presence of others at will.

In many ways, this is a machine-enhanced style of meditation. Many of the same types of focus that are used in other forms of meditation are incorporated into this technique in order to generate brainwave shifts. The main difference between this and other styles of meditation is the speed and style with which the "meditator" gets feedback about how his session is going. I am including this modality here because it has been so exhaustively documented to successfully encourage changes in subjects' brainwaves, accompanied by subjective reports of alleviation of their symptoms.

Papers demonstrating the success of neurofeedback include work on epilepsy,[71] ADD/ADHD,[72] learning disabilities,[73] anxiety disorders,[74] post-traumatic stress disorder,[75]

---

[70]Collura, Thomas. "EEG Biofeedback for Attention Deficit Disorder." Cleveland Clinic Foundation - Pediatric Grand Rounds, November 19, 1996. http://www.hackcanada.com/ice3/wetware/grounds.html. 5/16/05.

[71]-Kotchoubey, B., Strehl, U., Uhlmann, C., Holzapfel, S., Konig, M., Froscher, W., Blankenhorn, V., and Birbaumer, N. (2001). "Modification of slow cortical potentials in patients with refractory epilepsy: A controlled outcome study." *Epilepsia,* 42(3), 406-416.
-Sterman, M. B., and Lantz, D. (2001). "Changes in lateralized memory performance in subjects with epilepsy following neurofeedback training." *Journal of Neurotherapy*, 5, 63-72.
-Sterman, M. B. (2000). "Basic concepts and clinical findings in the treatment of seizure disorders with EEG operant conditioning." *Clinical Electroencephalography*, 31(1), 45-55.
-Kotchoubey, B., Busch, S., Strehl, U., and Birbaumer, N. (1999). "Changes in EEG power spectra during biofeedback of slow cortical potentials in epilepsy." *Applied Psychophysiology and Biofeedback,* 24(4), 213-233.
-Ayers, M. E. (1995). "Long-term follow-up of EEG neurofeedback with absence seizures." *Biofeedback and Self-Regulation*, 20(3), 309-310.
-Andrews, D. J., and Schonfeld, W. H. (1992). "Predictive factors for controlling seizures using a behavioural approach." *Seizure,* 1(2), 111-116.
-Daum, I., Rockstroh, B., Birbaumer, N.,Elbert, T., Canavan, A., Lutzenberger, W. (1993). "Behavioral treatment of slow cortical potentials in intractable epilepsy: Neuropsychological predictors of outcome." *Journal of Neurosurgery and Psychiatry*, 56 94-97.
-Cott, A., Pavloski, R. P., and Black, A. H. (1979). "Reducing epileptic seizures through operant conditioning of central nervous system activity: Procedural variables." *Science*, 203, 73-75.

[72] -Monastra, V. J., Monastra, D. M., and George, S. (2002). "The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention-deficit/hyperactivity disorder." *Applied Psychophysiology and Biofeedback*, 27(4), 231-249.
-Rossiter, T. (2002). "Neurofeedback for AD/HD: A ratio feedback case study." *Journal of Neurotherapy*, 6(3), 9-35.
-Nash, J. K. (2000). "Treatment of attention-deficit hyperactivity disorder with neurotherapy." *Clinical Electroencephalography*, 31(1), 30-37.
-Kaiser, D. A., and Othmer, S. (2000). "Effect of Neurofeedback on variables of attention in a large multi-center trial." *Journal of Neurotherapy*, 4(1), 5-15.

sleep disorders,[76] depression and addiction,[77] headache and other pain,[78] schizophrenia,[79] obsessive compulsive disorders,[80] autism,[81] and cognitive decline with aging,[82] among

---

-Swingle, P. G. (2001). "Parameters associated with rapid neurotherapeutic treatment of common ADD (CADD)." *Journal of Neurotherapy*, 5(4), 73-84.
-Albert, A. O., Andrasik, F., Moore, J. L., and Dunn, B. R. (1998). "Theta/beta training for attention, concentration and memory improvement in the geriatric population." *Applied Psychophysiology and Biofeedback*, 23(2), 109.
-Boyd, W. D., and Campbell, S. E. (1998). "EEG biofeedback in the schools: The use of EEG biofeedback to treat ADHD in a school setting." *Journal of Neurotherapy*, 2(4), 65-71.
-Alhambra, M. A., Fowler, T. P., and Alhambra, A. A. (1995). "EEG biofeedback: A new treatment option for ADD/ADHD." *Journal of Neurotherapy*, 1(2), 39-43.
-Shouse, M. N., and Lubar, J. F. (1979). "Sensorimotor rhythm (SMR) operant conditioning and methylphenidate in the treatment of hyperkinesis." *Biofeedback and Self-Regulation*, 4, 299-311.
[73] -Egner, T., and Gruzelier, J. H. (2001). "Learned self-regulation of EEG frequency components affects attention and event-related brain potentials in humans." *NeuroReport,* 12, 4155-4159.
-McKnight, J. T., and Fehmi, L. G. (2001). "Attention and neurofeedback synchrony training: Clinical results and their significance." *Journal of Neurotherapy*, 5(1-2), 45-62.
-Rasey, H. W., Lubar, J. E., McIntyre, A., Zoffuto, A. C., and Abbott, P. L. (1996). "EEG biofeedback for the enhancement of attentional processing in normal college students." *Journal of Neurotherapy*, 1(3), 15-21.
-Budzynski, T. H. (1996). Brain brightening: Can neurofeedback improve cognitive process? Biofeedback, 24(2), 14-17.
-Cunningham, M., and Murphy, P. (1981). "The effects of bilateral EEG biofeedback on verbal, visuospatial and creative skills in LD male adolescents." *Journal of Learning Disabilities*, 14(4), 204-208.
-Jackson, G. M., and Eberly, D. A. (1982). "Facilitation of performance on an arithmetic task as a result of the application of a biofeedback procedure to suppress alpha wave activity." *Biofeedback and Self-Regulation*, 7(2), 211-221.
-Lutzenberger, W., Elbert, T., Rockstroh, B., and Birbaumer, N. (1982). "Biofeedback of slow cortical potentials and its effects on the performance on mental arithmetic tasks." *Biological Psychology*, 14, 99-111.
[74]-Egner, T., Strawson, E., and Gruzelier, J. H. (2002). "EEG signature and phenomenology of alpha/theta neurofeedback training versus mock feedback." *Applied Psychophysiology and Biofeedback*, 27(4), 261-270.
-Brody, S., Rau, H., Kohler, F., Schupp, H., Lutzenberger, W., and Birbaumer, N. (1994). "Slow cortical potential biofeedback and the startle reflex." *Biofeedback and Self-Regulation*, 19(1), 1-12.
-Garrett, B. L., and Silver, M. P. (1976). "The use of EMG and alpha biofeedback to relieve test anxiety in college students." Chapter in I. Wickramasekera (Ed.), Biofeedback, Behavior Therapy, and Hypnosis. Chicago: Nelson-Hall.
-Hardt, J. V., and Kamiya, J. (1978). "Anxiety change through electroencephalographic alpha feedback seen only in high anxiety subjects." *Science*, 201, 79-81.
-Kirschbaum, J., and Gisti, E. (1973). "Correlations of alpha percentage in EEG, alpha feedback, anxiety scores from MAS and MMQ." *Archives fur Psychologie*, 125(4), 263-273.
-Moore, N. C. (2000). "A review of EEG biofeedback treatment of anxiety disorders." *Clinical Electroencephalography*, 31(1), 1-6.
-Norris, S. L., Lee, C-T., Burshteyn, D., and Cea-Aravena, J. (2001). "The effects of performance enhancement training on hypertension, human attention, stress, and brain wave patterns: A case study." *Journal of Neurotherapy*, 4(3), 29-44.
-Plotkin, W. B., and Rice, K. M. (1981). "Biofeedback as a placebo: Anxiety reduction facilitated by training in either suppression or enhancement of alpha brainwaves." *Journal of Consulting and Clinical Psychology*, 49, 590-596.
-Sattlberger, E., and Thomas, J. E. (2000). "Treatment of anxiety disorder with slow-wave suppression EEG feedback: A case study." *Biofeedback*, 28(4), 17-19.
-Wenck, L. S., Leu, P. W., and D'Amato, R. C. (1996). "Evaluating the efficacy of a biofeedback intervention to reduce children's anxiety." *Journal of Clinical Psychology*, 52(4), 469-473.
[75]-Graap, K., Ready, D. J., Freides, D., Daniels, B., and Baltzell, D. (1997). "EEG biofeedback treatment for Vietnam veterans suffering from posttraumatic stress disorder." *Journal of Neurotherapy*, 2(3), 65-66.
-Peniston, E. G., and Kulkosky, P. J. (1991). "Alpha-theta brainwave neuro-feedback therapy for Vietnam veterans with combat-related post-traumatic stress disorder." *Medical Psychotherapy*, 4, 47-60.
-Peniston, E. G., Marrinan, D. A., Deming, W. A., and Kulkosky, P. J. (1993). "EEG alpha-theta brainwave synchronization in Vietnam theater veterans with combat-related post-traumatic stress disorder and alcohol abuse." *Advances in Medical Psychotherapy*, 6, 37-50.
[76]-Feinstein, B., Sterman, M. B., and MacDonald, L. R. (1974). "Effects of sensorimotor rhythm training on sleep." *Sleep Research*, 3, 134.
-Sterman, M. B. (1977). "Effects of sensorimotor EEG feedback on sleep and clinical manifestations of epilepsy." Chapter in J. Beatty and H. Legewie (Eds.), Biofeedback and Behavior. New York: Plenum, pp. 167-200.
-Sterman, M. B., Howe, R. D., and Macdonald, L. R. (1970). "Facilitation of spindle-burst sleep by conditioning of electroencephalographic activity while awake." *Science*, 167, 1146-1148.
[77]-Hammond, D. C. (2001). "Neurofeedback treatment of depression with the Roshi." *Journal of Neurotherapy*, 4(2), 45-56.
-Baehr, E., Rosenfeld, J. P., and Baehr, R. (2001). "Clinical use of an alpha asymmetry neurofeedback protocol in the treatment of mood disorders: Follow-up study one to five years post therapy." *Journal of Neurotherapy,* 4(4), 11-18.
-Putnam, J. A., (2001). "EEG biofeedback on a female stroke patient with depression: A case study." *Journal of Neurotherapy,* 5(3), 27-38.
-Baehr, E., and Baehr, R. (1997). "The use of brainwave biofeedback as an adjunctive therapeutic treatment for depression: Three case studies." *Biofeedback*, 25(1), 10-11.

other areas. Each of these techniques encourages the production of certain brainwave states over others in order to relieve symptoms. Examples include teaching the production of beta waves for patients with ADD, alpha waves for pain and anxiety, and desynchronization of theta waves with elevated alpha and beta waves for patients with depression.

This research supports the claims made earlier in this paper on several different fronts. First, it ties brainwave phenomena to conscious phenomena in a varied and relevant manner, further supporting the oscillating neural network model of the brain and the importance of examining beta, alpha, and theta activity as part of understanding consciousness. Second, and more specifically and significantly, this literature elaborately demonstrates that brainwave states can be tied to various mental symptoms or "disorders"

-Kumano, H., Horie, H., Shidara, T., Kuboki, T. et al. (1996). "Treatment of a depressive disorder patient with EEG-driven photic stimulation." *Biofeedback and Self-Regulation,* 21(4), 323-334.
-Saxby, E., and Peniston, E. G. (1995). "Alpha-theta brainwave neurofeedback training: an effective treatment for male and female alcoholics with depressive symptoms." *Journal of Clinical Psychology*, 51, 685-693.
-Schneider, F., Heimann, H., Mattes, R., Lutzenberger, W., and Birbaumer, N. (1992). "Self-regulation of slow cortical potentials in psychiatric patients: Depression." *Biofeedback and Self-Regulation*, 17, 203-214.
[78]-Ham, L. P., and Packard, R. C. (1996). "A retrospective, follow-up study of biofeedback-assisted relaxation therapy in patients with posttraumatic headache." *Biofeedback and Self-Regulation*, 21(2), 93-104.
-Matthew, A., Mishm, H., and Kumamiah, V. (1987). "Alpha feedback in the treatment of tension headache." *Journal of Personality and Clinical Studies,* 3(1), 17-22.
-Pelletier, K. R., and Pepper, E. (1977). "Developing a biofeedback model: Alpha EEG feedback as a means for pain control." *International Journal of Clinical and Experimental Hypnosis*, 25, 361-371.
-Coger, R., and Werbach, M. (1975). "Attention, anxiety, and the effects of learned enhancement of EEG alpha in chronic pain: A pilot study in biofeedback." Chapter in B. L. Drue, Jr. (Ed.), Pain Research and Treatment. New York: Academic Press.
-Lehmann, D., Lang, W., and Debruyne, P. (1976). "Controlled EEG alpha feedback training in normals and headache patients." *Archives of Psychiatry*, 221, 331-343.
-McKenzie, R., Ehrisman, W., Montgomery, P. S., and Barnes, R. H. (1974). "The treatment of headache by means of electroencephalographic biofeedback." *Headache*, 13, 164-172.
-Siniatchkin, M., Hierundar, A., Kropp, P., Kuhnert, R., Gerber, W-D., and Stephani, U. (2000). "Self-regulation of slow cortical potentials in children with migraine: An exploratory study." *Applied Psychophysiology and Biofeedback*, 25(1), 13-32.
-Tansey, M. A. (1991). "A neurobiological treatment for migraine: The response of four cases of migraine to EEG biofeedback training." *Headache Quarterly: Current Treatment and Research*, 90-96.
[79]-Gruzelier, J. (2000). "Self regulation of electrocortical activity in schizophrenia and schizotypy: A review." *Clinical Electroencephalography*, 31(1), 23-29.
-Gruzelier, J., Hardman, E., Wild, J., Zaman, R., Nagy, A., and Hirsch, S. (1999). "Learned control of interhemispheric slow potential negativity in schizophrenia." *International Journal of Psychophysiology*, 34, 341-348.
-Schneider, F., Rockstroh, B., Heimann, H. et al. (1992). "Self-regulation of slow cortical potentials in psychiatric patients: Schizophrenia." *Biofeedback and Self-Regulation*, 17, 277-292.
[80]Hammond, D. C. (2003, in press). "QEEG-guided neurofeedback in the treatment of obsessive compulsive disorder." *Journal of Neurotherapy*, 7(O)
[81]-Jarusiewicz, B. (2002). "Efficacy of neurofeedback for children in the autistic spectrum: A pilot study." *Journal of Neurotherapy*, 6(4), 39-49.
-Sichel, A. G., Fehmi, L. G., and Goldstein, D. M. (1995). "Positive outcome with neurofeedback treatment of a case of mild autism." *Journal of Neurotherapy*, 1(1), 60-64.
[82]-Albert, A. O., Andrasik, F., Moore, J. L., and Dunn, B. R. (1998). "Theta/beta training for attention, concentration and memory improvement in the geriatric population." *Applied Psychophysiology and Biofeedback*, 23(2), 109. Abstract.
-Budzynski, T. H. (1996). "Brain brightening: Can neurofeedback improve cognitive process?" *Biofeedback*, 24(2), 14-17

(which could and probably should be treated at as states of consciousness in themselves, implying their impermanence or at the very least their malleability) and that those symptoms can be systematically altered and reconfigured with the appropriate attention to brainwave states. Third, this notion, that brainwaves have something to do with mental disorders, was touched upon in the neural network overview[(see footnotes 19-23)], and gets further support with this applied research. Later in this paper I will argue that attention to repetitive music can systematically alter brainwave states. I will also briefly present evidence that music alters mood and has been useful to treat various mental disorders. Because neurofeedback has been demonstrated to help treat disorders by altering brainwave patterns, this seems to suggest that music is likely alleviating various mental disorders by altering brainwave patterns in a similar manner.

Chapter 3: Review of Religious Studies/Anthropological Commentary on Auditory Driving

A. An Overview Up To 1980:

There has been debate since the early 1950's about the extent to which different psychological and social-environmental factors play into the induction of trance states in a variety of ritual contexts. Specifically, the question: "Can music (alone or in context) induce trance?" has had a wide variety of answers from different researchers. Gilbert Rouget has made the most intense effort of any anthropologist in the last 25 years to answer this question, summarized in his book Music and Trance: A Theory of Relations between Music and Possession, published in 1980. After a long discussion of various ritual trances involving music, he ends the first part of his book with a look at the existing anthropological writing on the neurophysiological theory of the effects of drumming and other repetitive auditory stimulation. The centerpiece of this discussion is Andrew Neher's laboratory study of auditory driving published in 1962. This particular study had been the basis of a large amount of speculation about trance in the years between 1962 and 1980. For this reason, Rouget felt he had to address Neher's claims, especially because he disagreed with them so flagrantly. I am going to review both Rouget's work on Neher and some of the work that Rouget cites supporting various arguments for and against Neher's auditory driving hypothesis. Because so many of the claims that I will make later in this paper relate to Neher's work, a discussion of Rouget's account and criticisms of Neher's study can serve to both highlight the questions regarding this topic that still exist today and point out how some of the new science that has been done since

1980 can address many of Rouget's concerns. I'll end the chapter with a brief discussion of the work of several contemporary anthropologists who've written about auditory driving.

Rouget's survey of anthropological writings on music and trance phenomena will begin the larger conversation about Neher and the induction of trance through auditory stimuli in general. Rouget begins in 1955 with Dr. Charles Pidoux, a physician and ethnopsychiatrist who studied possession cults in Mali. He hypothesized that drumbeats might act upon "different levels of the neural axis."[83] This sort of statement was representative of the level of detail of the anthropological discourse on trances evoked by ritual drumming until Neher's lab work in 1961 and his anthropological writings on that work in 1962. In the years following, which coincided with the psychedelic revolution and a new interest in non-ordinary states of consciousness, many papers and various theories on the subject emerged. Rodney Needham seems to be one of the first anthropologists post-1962 to write about music and trance in his article, "Percussion and Transition," published in 1967 in *Man*. According to Rouget, Needham's view begins with the claim: "All over the world…percussion…permits or accompanies communication with the other world." Rouget writes, the problem then, according to Needham, was to discover what the exact relation was between the concept of spiritual existence [NOSCs] and this "non-cultural affective appeal of percussion."[84] Needham seemed to view percussion, regardless of rhythm, melody, or repetition as the key to the induction of trance. He seemed convinced that *sound* was what was important about it. He goes on: "There is no doubt that sound-waves have neural and organic effects on

[83] Rouget, 175.
[84] Rouget- pg. 170.

human beings, irrespective of the cultural formation of the latter…" and adds later that trance occurs as a result of disturbances brought about by the sounds of the drums, "in the inner ear, an organ which modulates postural attitudes, muscular tonus, breathing rhythms, heartbeat, blood pressure, feelings of nausea, and certain eye reflexes." In 1968 W.C. Sturtevant wrote in a letter to the editor of *Man* headed "Categories, Percussion and Physiology," that the effects of trance and music are so widespread because "some universal psychological or physiological mechanism is at work."[85] Anthony Jackson also took on a brain-phenomena line of reasoning, in his article "Sound and Ritual" (1968) when he states that "since the brain is a common denominator to all mankind, it follows that what is true at the neuro-physiological level must be universally true."

According to Rouget, all three authors just mentioned accept as proven "a theory according to which the rhythmic beating of this instrument [a drum] is capable of producing a particular effect upon the central nervous system [the induction of a non-ordinary state] and thereby triggering convulsions." This line refers to Neher's study, and includes one of the central biases that Rouget holds towards this theory throughout his analysis. Rouget is very caught up in the idea that Neher was claiming to be able to induce the same trance phenomena in a lab setting that one would see during a ritual. Instead, it seems that Neher attempted to induce a NOSC that had related aspects to trance ritual NOSCs- he never claimed that he could induce the same full-blown trances in his lab that had been observed in highly culturally-conditioned ritual settings. He seemed to be interested in a different question: whether he could induce an NOSC with drumming at all, per specific tempos. It hadn't been scientifically demonstrated, and Rouget jumps way ahead when he criticizes Neher for not having induced an extremely

[85] Rouget, pg. 171.

deep trance phenomenon like convulsions. This kind of detail is certainly relevant to Rouget's study of possession trances, but not to the tempo-specific inquiry Neher was making. I'll return to this point later in this discussion.

Sheila S. Walker addresses the relationship between trance and music in her chapter on the neurophysiological aspects of possession in her book Ceremonial Spirit Possession in Africa and Afro-America, written in 1972. She also believed that drumming and trance were intimately related: "The most fundamental element of possession is the presence of neurophysiological changes, [and these] are most frequently produced by sensory bombardment, usually in the form of sonic driving of the drum rhythms."[86] She adds later, "the hypnotic state is triggered by the altered state of consciousness and changes in body ego produced by the neurophysiological effects of the rhythmic drumming." She refers here to hypnosis, and seems to make a separation between it and the NOSC she is describing.

Rouget moves from here to briefly sum up the other contemporary authors he would like to address in his treatment of Neher's paper who he feels have far too readily accepted Neher's claims. In short, other than authors previously mentioned, Neher's paper has been praised on the "pages Raymond Prince (1968, 133-35) devoted to it in his article on encephalography and research into possession states, by the allusions made to it during the 1968 Paris Colloquium by various ethnologists, and by the reference T. F. Johnston (1972, 30) makes to it in his article on possession music among the Tsonga, in which it is clear that he, too, regards it as a given." Rouget ends, "I therefore have no choice but to examine this theory in fairly great detail."[87] There were some

[86] Pgs. 17-24 in Ceremonial spirit possession in Africa and Afro-America referenced in Rouget.
[87] Rouget, pg. 172.

anthropologists at the time who rejected Neher's claims, preferring a line of reasoning that included hypnosis and other culturally conditioned aspects of trance. I'll present some of their ideas after a full treatment of Neher's study.

Neher published a lab study, *Auditory Driving Observed with Scalp Electrodes in Normal Subjects,*[88] in 1961 and followed it in 1962 with an anthropological paper *A Physiological Explanation of Unusual Behavior in Ceremonies Involving Drums*[89] on his experiments from the previous year. Neher explains that this latter article deals with behavior "often described as a trance state, in which the individual experiences unusual perceptions or hallucinations. In the extreme cases contraction of the body and generalized convulsion are reported." Rouget seems to totally miss the clause about "extreme cases" when he claims that Neher's thesis is that "intermittent acoustic stimuli having particular characteristics and are capable of 'driving' the brain's alpha rhythm and thereby triggering convulsions." This was a take on Neher's work that emphasizes areas that Neher probably never intended to emphasize and it simply misses the point in other ways. Other than making no claims about inducing convulsions, Neher was attempting to induce more than just an alpha state, which becomes important later on.

Rouget explains that the particular claims of the thesis are: "(1) with respect to intermittency, a bass frequency corresponding more or less to the frequency band of the alpha rhythm, which can vary from eight to thirteen cycles per second, according to the individual; and (2) with respect to the acoustical spectrum, a predominance of bass frequencies (musical frequencies in this case) since they are capable of transmitting more energy to the brain than higher frequencies without doing damage to the ear." Rouget

[88] Neher A. "Auditory driving observed with scalp electrodes in normal subjects." *Electroencephalogr Clin Neurophysiol*. 1961 Jun;13:449-51.
[89] Neher, A. "A Physiological Explanation of Unusual Behavior in Ceremonies Involving Drums". *Human Biology* 34, 1962. 151-160.

misunderstood Neher's first claim. Neher was looking for an auditory driving response, not necessarily one specific to a certain frequency range. Neher explains that he's based much of his work off of experiments done in the 30s, 40s, and 50s, with flashing light stimuli that were effective at inducing driving responses. In other words, in the lab, if they flashed a light at 7 cycles per second into the eyes of a subject, they would see peaks 7 times per second in the brainwave EEG readouts, which corresponded with an alpha state in the subject. The scientists described the NOSCs they produced from this stimulation as "behavioral disturbances" that were sometimes as intense as "epileptic fits." [90]

Neher was interested in seeing if he could produce a similar brainwave driving response with auditory stimuli to that observed with light stimuli. But he didn't restrict himself to the alpha range as Rouget suggests. He used 4 stimuli: 3, 4, 6, and 8 beats per second. The 3 and 4 Hz stimuli fall into the theta range, and the 6 and 8Hz stimuli fall into the alpha range. Neher was interested not in the general range of alpha, but in the specific tempos he was playing his subjects, a point Rouget seems to have missed entirely. Neher's hypothesis was that if he played a 3 Hz stimuli for a subject, the subjects brainwaves would entrain to 3 Hz, and he would be able to see 3Hz peaks in the

[90]-Livanov, M. N. And Poliakov, K. L. "[Electrical processes in the rabbit's cortex during the development of conditioned response to rhythmic stimulation.]" *Bull. Acad. Sci.* USSR, 1945, 3:286 307.
-Loyd-Smith, O. L. And Henderson, L. R. "Epileptic patients showing susceptibility to photic stimulation alone." *Electroenceph. clin. Neurophysiol.*, 1951, 3:378.
-Walter, V. J. And Walter, W. G. "The central effects of rhythmic sensory stimulation." *Electroenceph. cliu. Neurophysiol.*, 1949, 1: 57-86.
-Ulett, G. A., Brockman, J. C., Gleser, G. And Johnson, A. "Determination of convulsive threshold by photo-pharmacologic stimulation: a study of technique and reliability." *Electroenceph. clin. Neurophvsiol.* 1955, 7:597-607.
-Ulett, G. A. And Johnson, L. C. "Pattern stability, and correlates of photic electroencephalographic activation." *J. nerv. ment. Dis.,* 1958, 126:153 168.
-Mundy-Castle, m. C. "An analysis of central responses to photic stimulation in normal adults." *Electroenceph.clin. Neurophysiol.,* 1953, 5:1 22.
-Remond, A. "Photo-Metrazol activation." *Electroenceph.cliu. Neurophysiol.,* 1952, 4:265 270.
-Ulett, G. A. "Preliminary observations of convulsive, and subconvulsive treatments induced by intermittent photic stimulation." *Amer. J. Pschiat.*, 1953, 109: 741 748.
-Richardson, A. & McAndres, F., "The Effects of Photic Stimulation and Private Self-consciousness on the Complexity of Visual Imagination Imagery." British Journal of Psychology, 81,381-394, 1990.

EEG. The same would be the case for 8Hz, or the other two. He played the stimuli in different orders for each subject to control for any biasing the presentation of the stimuli might cause the subjects, and varied the lengths of time. 3, 4, 6, and 8 Hz were all played for 40 seconds a piece to each of the 10 volunteers and then there was a longer 4Hz period that lasted 4 minutes. After the data analysis, Neher found that a driving phenomenon was observed in all 10 subjects. Some subjects responded more dramatically than others, but a change in the pattern of their brainwaves was observed across them all. This was an exciting finding, especially in light of the state of the science at the time. Up to this point, no one had proven that you could affect the pulsations of brainwaves with sonic stimuli. They knew that sound had a social effect on people, but this particular physiological impact was previously unconfirmed.

In addition to the reported brainwaves shifts, Neher adds a list of reported subjective symptoms experienced by one or more subjects that includes:

> …fear, astonishment, amusement, back pulsing, muscle tightening, stiffness in chest, tone in background, humming, rattling, visual and auditory imagery." He also notes, "Involuntary eyeblinks, which are usually the first sign of a myoclonic reaction that may spread and lead to a convulsion, occurred in the records of, and were reported as bilateral by, half of the subjects. This is a high proportion compared to results from photic driving (Ulett *et al.*1955). By Fisher's Exact Probability Test, eyeblink response was shown to occur in those subjects who showed greatest driving. It is interesting that a subject who showed high driving had previously experienced rhythmic eye-blinks from drums beating in a band.

The correlation between the observed brainwave shifts and the subjective reports he collected seemed to make a strong case for the viability of his observations.

One complication of the study was the fact that the faster stimuli (6 and 8Hz) were recorded at a lower volume than the slower stimuli, and Neher did not observe the

same intensity of a driving response. It's likely that the difference in volume could account for that result, given the vital role that attention and concentration play in the induction of trance. A softer stimulus could have resulted in a wandering of the subjects' attention, which would have resulted in a greatly reduced driving response, a point that Rouget either did not understand or did not think about.

Rouget finishes: "On the strength of these experiments, Neher feels he is justified in concluding that: (1) the responses he obtained in his laboratory with auditory stimulation are "similar" to those obtained by other with 'photic driving'; and (2) they confirm the proposed hypothesis, namely, that the 'unusual behavior [[91]read: the convulsions] observed in drum ceremonies is mainly the result of rhythmic drumming which affects the central nervous system.'"[92]

From here, Rouget jumps into a list of 4 criticisms that I'd like to address one at a time. He begins, "I should like to point out first that whereas, according to Neher, light stimulation has indeed brought on behavioral disorders that can reach the stage of 'clinical psychopathic states and epileptic seizures,' he, Neher, has managed to produce nothing more than 'involuntary eye-blinks.'"[93] First, this is only partly correct. He did manage to elicit a range of subjective symptoms from his subjects, in addition to the shifts in brainwaves, the latter of which is hardly trivial. Second, Neher only ran the subjects for 4 periods of 40 seconds, and then once for 4 minutes. This doesn't begin to approach the time frame of most trance rituals, which often go on for hours. Even according to Rouget, trance is not immediate.[94] It usually builds gradually over the course of at least a half-hour of dancing and ritual preparation. So it seems reasonable

[91] Rouget's addition
[92] Rouget, 174.
[93] Ibid.
[94] Rouget, 175-182.

that deep trance could not have been expected in this setting. Rouget's second claim builds on the first, but misses the context of the experiment once again: "Second, there is no reason to accept without further proof that the behavioral disorders observed in a laboratory under the effect of intermittent stimuli of any kind, visual or auditory, are of the same nature as those observed in possession trances. There are many different kinds of convulsion." At this point he goes on to explain several different ways that convulsions manifest in different ritual settings among different people. His claim is reasonable, but it does not address the actual circumstances of the laboratory, which could not have led to the same sort of trance as in a ritual setting.

Neher never made light of the notion that that trance is culturally conditioned, he simply wanted to try to tease out the auditory portion of the rituals he was observing from their larger context. His model is based on the idea that there are certain physical brainwave states that must be present in order for the kind of trance state that Rouget is talking about to manifest. Once the brainwaves have shifted to that state, it is possible to induce a range of states of consciousness that reflect that baseline brainwave state. These states act like a template or a medium of consciousness upon with other conscious processes can take place. In this case, Neher seems to claim that an alpha or theta state is a necessary precondition for experiencing any of the much more complicated trance states that Rouget is talking about. Once someone has entered one of these highly subjective states (more so with theta) the cultural circumstance and association can take over and induce the culturally conditioned trance. It would be very unlikely to see such a trance state in a lab setting coming from volunteers who do not know about ritual trance states and have never been in one nor seen anyone in one, unlike almost every trancer

Rouget is interested in. Given the proper context and conditioning, there is reason to believe that the baseline physiological phenomena we see in the laboratory are intimately related to the sorts of "pathological" or "epileptic" states we see in deep trance phenomena.[95] In addition, hypnotic phenomena of a similar variety have been compared to drumming induced NOSCs in multiple papers and have been shown to be extremely similar.[96]

Rouget's third criticism pertains to the laboratory stimulation method itself. "Third, a priori, the kind of parameters chosen for the stimulation casts doubt upon the experimental value of the procedure. The auditory stimuli used in the laboratory, being totally constant in form and intensity, have in practice very little in common with the constantly varying stimuli provided by drums played in possession séances." This is an important point and I think it can be reconciled. It's true that in a ritual setting the drums or whatever instruments are involved would often be played by people who get tired and distracted as the ritual goes on. As their attention wanders, their playing would change. Their volume would shift, and probably their rhythms would too. But this would all occur within a finite range. And if the volume got too low, or the tempo and rhythm changed too much, the ritual would certainly be messed up. There are standards among every culture for the way a ritual is supposed to take place and the performers are usually aware of the expectations for their playing. In many rituals there are several musicians involved. This would help keep the playing consistent and on track. The constancy of

---

[95] Winkelman, Michael. "Trance States: A Theoretical Model and Cross CulturalAnalysis." *Ethos*, 1986:14: 174-203.
[96] -Szabó, Csaba. "*The effects of monotonous drumming on subjective* experiences." Music Therapy Today Vol. V (1) Jan. 2004
-Winkelman, Michael. "Complementary Therapy for Addiction: 'Drumming Out Drugs.'"*Am J Public Health* 2003; 93: 647-651.
-Woodside, LN *et al*. "Monotonous Percussion Drumming and Trance Postures: A Controlled Evaluation of Phenomenological Effects." *Anthropology of Consciousness*. 1997, Vol. 8, No. 2-3: pp. 69-87.
-Maurer RL *et al*. "Phenomenological experience in response to monotonous drumming and hypnotizability." *Am J Clin Hypn*. 1997 Oct;40(2):130-45.

the laboratory stimuli represent an average for the specific volumes and the tempo ranges for any given piece of music during a ritual. The 3Hz stimuli, for example, stand in for drumming played with the strong beats pulsing at about that tempo. It's the same for the other tempos. And as a stimulus in general, the use of any repetitive auditory stimuli should suffice to mimic the properties of the ritual music of interest, as long as it was loud enough and aesthetically offending to the listener**.**

Lastly, Rouget objects to the auditory driving hypothesis on the grounds that the range of tempos is too large, and that if this model is correct, people should become entranced any random time they hear drumming:

> This means, ultimately, that the phenomena in question can occur when drums are struck at a speed varying from, let us say, twelve beats per second to four beats per second; in other words, when they are played at anywhere between 240 beats per minute and 720. These cadences cover the whole spectrum of tempi from *moderato* to *prestissimo* and beyond. So, unless, it is slow, drumming of any kind must therefore be able to trigger 'driving.' In other words, every time a drum is played, or almost, we should expect to see people go into convulsions. At least that would be the normal conclusion of Neher's arguments. Needless to say, this makes no sense. If Neher were right, half of Africa would be in a trance from the beginning of the year to the end.[97]

This assertion makes several claims. First I'd like to address the range of tempos that Rouget is talking about. As he concludes, drumming of any tempo can trigger driving. He regards this as absurd. But this is not a phenomena relegated to the possession trance realm. Rouget is correct that music of any tempo can induce trance, but it depends on what kind of trance he's talking about. He clearly did not consider that different tempos might have different effects. Second, Rouget should not expect everyone that goes into an NOSC to go into convulsions. In my reading about NOSCs, convulsions have not been a terribly common occurrence. They occur during only some trances, usually

[97] Rouget, 175.

possession trances, but not among most meditative states, hypnotic states, or the changes in states of consciousness that go on as a person falls asleep. This returns to the idea that states of consciousness can act like springboards for a range of states of consciousness within that given brainwave state (gamma, beta, alpha, theta, delta). The nature and intensity of a trance also entirely depends on the cultural situation and the expectations of the trancer, as it was emphasized earlier. In certain cases, like among epileptics, convulsions can be induced by stimuli like flashing lights, but that kind of physiological factor is even specific to photosensitive epileptics.[98]

Third, and this point is crucial to understanding auditory driving, not everyone listening to a piece of music or standing around at a ritual would go into trance even if auditory driving did exist. Would their brainwaves shift? They might, but it would probably depend on how much attention they were paying to the sounds around them. Sound does not seem to work like medications on an attentional level. If you take a medication, generally it will alter your physiology regardless of whether you pay any attention to it. Music works likely does not work the same way, given that all of the examples I know of auditory driving involve intense concentration on a sound. It seems to be that when your state of consciousness shifts, your state of attention does as well. And very relevantly, the kinds of shifts in consciousness that go on when a person is beings stimulated by sound or light are being mediated by consciousness itself. Attention, in this context, could be called the mover of consciousness. The more attention a person pays to a stimulus, the more potently it will affect their state. An analogy can be drawn to the way shifts in consciousness occur during meditation. The more engrossed in the meditation you become, the more you are focused only on what

[98] "Photosensitive Epilepsy." http://www.epilepsy.org.uk/info/photo.html. 2005. 5/5/05.

you are doing, the deeper your altered state becomes and the more difficult it is to shift out of it. The mild meditative states we enter all day long as we get engrossed in one thing, and lose our awareness of the outside world for a short period of time, follow this same model. This is why beauty is entrancing. It is inherently- for something to be beautiful you need to find it interesting in a way that is engrossing, that catches your attention and holds it. This is also why just hearing music or experiencing other stimulation in the environment doesn't always throw you into a trance. You need to give yourself to it to become entranced—your attention needs to be there. The more completely your attention is focused on a given stimulus the more it affects you.

So in a ritual situation, the person designated to go into trance is going to be the person in the gathering who is most focused on the trance-stimulating phenomena—the dancing, the music, the physical sensations he's experiencing, the sights of ritual symbols and dress all around, the attention he's getting from the crowd, his memories of past trancers and his own trances. He's totally absorbed. That's not to say that the audience isn't absorbed. It's unthinkable that during festivals where music goes all day the people in the audience aren't affected by it. But maybe they go into a light alpha state, which could come with relaxed concentration, rather than a theta state, which might result in a deeper trance, only available through more intense concentration.

B. Some Competing Theories of Trance:

Rouget moves from his denouncement of Neher's theory of trance to a couple of different theories he seems to find viable. These alternative theories certainly play into the NOSC experience, but I don't believe that they are necessarily the best explanations

for how one enters an NOSC. The first idea is essentially that an NOSC is induced by the exhaustion the trancer experiences after hours of dancing and listening to music. In 1935 Nina Rodrigues, a Brazilian doctor of medicine, referred to the "'unusual monotony' of the drumming, capable of rivaling all the various means of inducing hypnosis by fatigue and concentration."[99] H. A. Junod, a South African anthropologist, noted in 1913 that "the music acts largely by overloading the nervous system, by a physical harassment, one might say, that reduces the patient to a state of exhaustion and nervous crisis."[100] The auditory evoked responses in various EEG studies of trance drumming indicate that this degree of stimulation is not necessary to induce trance, but certainly would play a part in long trance ceremonies or extended meditative endeavors. In 1965 Katerina Kakouri, describing the trance of the Anastenarides in Thrace, says that music acts "directly on the nervous state of those involved, with the 'heavy sound' of the drum and its 'persistent beat' which gets on the nerves of the initiates or on the 'strained nerves of the possessed."[101]

Another take on trance comes from Herskovitz. His view is related to hypnotic phenomena, but emphasizes Pavloivan ideas[102] of associating the trance with various cultural stimuli to bring it on at culturally and ritually appropriate times. Rouget writes that Herskovitz, "wanted to show in this way that possession trance should be viewed as a normal state resulting from apprenticeship to a cultural model, itself determined by history." Herskovitz comments:

> The psychological process we have in view is that which is very clearly defined by the expression 'conditioned reflex,' which means that every time a specific stimulus is applied, there is a corresponding reaction, the

[99] Rouget, 176.
[100] Ibid.
[101] Ibid.
[102] http://nobelprize.org/medicine/educational/pavlov/readmore.html 4/28/05.

> individual having been accustomed to behave in this way in response to an agreed-upon signal. There is nothing abnormal in this process- quite the contrary, since it represents the psychological level at which a large part of our existence is lived. Now let us imagine a person who has been brought up in a cultural environment in which there is a profound belief in divinities, and in which he has been taught since childhood that he will receive, or be capable of receiving, one of these divinities; that these deities are summoned by the intermediary of specific drum rhythms and chants, to which they respond by descending upon the heads of those chosen to serve them. There is a good chance that, in the presence of the stimulus constituted by all the factors of a given situation conforming to the indications I have just given, the response will not be long delayed, and that possession will take place.[103]

In the end Rouget seems to believe in some combination of all of these factors but puts the most stock in the way music evokes emotion in the listener, which leads to trance as the emotion gets more intense. I would argue in response that it takes a certain state of mind to become completely enveloped in emotion. In a musical case, according to the auditory driving model, given a tempo of 4 Hz, your analytic processing is being tempered as your beta waves decrease, as your memories, many of which are emotional, rise to dominate your consciousness as your alpha and theta waves increase in power. Moving into that altered state would be a combination of the music, which first starts to move you into an ASC, and then the loop that's created by the intensification of your emotions and resultantly the intensification of your reactions to outside stimuli, which would then cause even more intense emotional responses to that stimuli, which all the time would cause you to become more and more attentionally engrossed, resulting in the deepening of the trance.

[103] Rouget, 177.

C. Writing on Rhythmic Entrainment Since 1980:

Contemporary anthropologists such as Judith Becker, Pat Moffitt Cook, and Don Campbell seem to accept rhythmic entrainment as a neurological phenomenon, but don't add much systematic proof beyond their predecessors' observations. This is one of the main reasons that it seems necessary to add some scientific rigor to this dialogue. Becker echoes much of what we've heard thus far in her 1994 article, "Music and Trance," including some of the arguments I put forth to counter Rouget:

> I define trance as a state of mind characterized by intense focus, the loss of the strong sense of self and access to types of knowledge and experience that are inaccessible in non-trance states. While Rouget prefers to distinguish between states of 'trance' and 'ecstasy,' I prefer a generic category of 'trance' that includes meditative states, possession trance, shamanic trance, communal trance, aesthetic trance and isolated moments of transcendence. Trance states can be of different kinds: there is the trance of the performer who feels herself to be one with the music she plays; the mild trance of the listener whose whole attention becomes focused on the music; possession trance, in which one's self appears to be displaced and one's body is taken over by a deity or a spirit; the trance of Sufi mystics who feel themselves unified with Allah; or the meditation trance of Vajrayana Buddhists, who feel themselves become the deity. Trance is not a digital on-off state. There can be many degrees of trance. Trance is often a learned behavior and thus nearly always bears the imprint of a particular society's beliefs about it.[104]

Her discussion of rhythmic entrainment includes an extended discussion of Neher's study and several ritual examples of trance from Bali, Java, and Kerala in Southern India that she believes are closely tied to this phenomenon. She concludes:

> One can reasonably assume that human brains become entrained to the rhythms of music and that these entrained rhythms involve not only acoustic and sensory motor areas of the brain, but areas in many other cortical and sub-cortical areas. Memory, past history and emotions become a part of the rhythmically pulsating brain.[105]

[104] Becker, pg. 41-42.
[105] Becker, pg. 49.

Like the rest of the anthropologists surveyed here, Becker lacks scientific evidence for her confident stance on entrainment. She reflects of Neher's study, which is the only lab-based source she references, that: "As scientific studies go, it does seem somewhat thin and inconclusive." [106]

Don Campbell, pioneer of the "Mozart Effect,"[107] which describes the phenomenon of listening to Mozart with a subsequent elevation in IQ[108], is a well-known researcher in the area of musicology. He writes extensively about the physiological reactions that sound can elicit in the human body in his chapter on "The Healing Properties of Sound and Music" and claims early on that "It has been repeatedly demonstrated that brainwaves can be modified by music and self-generated sounds," but completely neglects to reference where any of this research has actually been done.

Pat Moffitt Cook, an ethnomusicologist and founder of the Open Ear Journal, a publication dedicated to the exploration of music perception, adds embarrassingly little to this dialogue. In her 2002 article, "Music, Imagery, and Healing," she claims, "The brain is stimulated to match the pulse of the music or entrain itself to their rhythm, a phenomenon known as "acoustic brainwave entrainment," and references herself as proof that this is true. She goes on to make many more claims based on this statement about brainwaves and their interaction with sound of various kinds. And what does this scholar point to as support for her analysis? It turns out to be a booklet from a set of commercial CDs she's been selling on the side to help people sleep, relax, and concentrate. She is a highly respected researcher in this field, and this is the best she could find, in 2002!

---

[106] Becker, pg. 48.
[107] Campbell, Don. The Mozart Effect. NY: Avon Books, 1997.
[108] -Rauscher, F.H., Shaw, G.L. and Ky, K.N. "Music and spatial task performance." *Nature,* 1993, 365: 611.
-Rauscher, F.H., Shaw, G.L. and Ky, K.N. "Listening to Mozart enhances spatial temporal reasoning: towards a neurophysiological basis." *Neurosci. Lett.,* 1995, 195: 44-47.

It seems to me that there is a gaping whole in this body of research. I think it's possible that so many different anthropologists assumed that this phenomenon was happening that they all ended up just convincing each other that it really was the case, by referencing one another over and over again, and never actually verified whether it was true or not. Because the ramifications of this sort of phenomenon are *massively important* to the understanding of music, its healing properties, various therapeutic methods related to it, and virtually every religious ritual on earth, it seems to me that more investigation into the science of these claims is more than warranted. The following chapter will detail the existing science that supports the claim that rhythmic auditory stimulation induces a shift in human brainwaves to the tempo of the stimulation.

Chapter 4: Scientific Evidence of Auditory Entrainment

As I've mentioned throughout this paper, direct scientific evidence of brainwave changes due to music, especially those that include relevant details about the subjective or phenomenological experiences of the individuals being tested, is hard to come by. The following is a survey of the existing work that has been done on the entrainment of human brainwaves by repetitive monaural auditory stimuli. It will be followed by a discussion of binaural stimulation, and then photic stimulation in an effort to draw the parallels between these different forms of stimulation and their subjective attributes, along with their evoked brainwave responses. I will argue that because binaural beats and rhythmic flashes seem to induce specific states per tempo, auditory beats should too. I'm using these examples because of the lack of lab evidence that monaural beats induce specific brainwave, whole-brain (in the alpha-state sense) states. But it seems significant that these three forms of stimulation are extremely related in the subjective states of consciousness that they seem to induce. I will highlight some of these subjective attributes as I discuss the brainwave alterations each type of stimulation brings on.

In general, brainwave entrainment has been observed in multiple sensory modalities. The frequency following response (FFR), is a term used to describe sensory brainwave entrainment in some of the literature.[109] As far as these particular studies report, auditory and photic entrainment has only occurred on a localized level, likely due

[109]-Gerken, G. M., Moushegian, G., Stillman, R. D., & Rupert, A. L. (1975). "Human frequency-following responses to monaural and binaural stumuli." *Electroencephalography and Clinical Neurophysiology*, 38, 379-386.
-Sohmer, H., Pratt, H., & Kinarti, R. (1977). "Sources of frequency following responses (FFR) in man." *Electroencephalography and Clinical Neurophysiology,* 42, 656-664.
-Stillman, R. D., Crow, G., & Moushegian, G. (1978). "Components of the frequency-following potential in man." *Electroencephalography and Clinical Neurophysiology*, 44, 438-446.
-Yaguchi, K., & Iwahara, S. (1976). "Temporal sequence of frequency specific and nonspecific effects of flickering lights upon the occipital electrical activity in man." *Brain Research*, 107, 27-38.
-Rodenburg, M., Verweij, C. and Van den Brink, G. (1972) "Analysis of evoked responses in man elicited by sinusoidally modulated noise." *Audiology*, 11: 283--293.

to the brief periods of stimulation involved, and did not result in subjective reports of whole-brain shifts in states of consciousness. Other general evidence that brainwave entrainment exists comes from evidence of brainwave entrainment to repetitive tactile stimuli in cats[110], monkeys[111], and humans.[112] Brainwave entrainment of a non-sensory kind has also been observed. Gavalas reported a driving response in cats and monkeys to low-level, low-frequency electrical and VHF fields.[113] The notion that brainwave entrainment can take place in this multi-modal lends support to the hypothesis that brainwave entrainment takes place in response to auditory stimuli.

Additional parallel support for this brainwave hypothesis can come from the consistency with which our other biological systems can become entrained. Leaving the other modes of stimulation aside, respiration and heart-rate,[114] motor movements[115], and even the subtle body movements of people in conversation will synchronize[116] to an auditory stimulus.

To be clear, monaural beats refer to stimuli like drums, chants and other sounds where essentially the same sound is presented to both ears at once in an ongoing,

---

[110]Pompeiano, O. and Swett, J.E. (1962) "EEG and behavioral manifestations of sleep induced by cutaneous nerve stimulation in normal cats." *Arch. ital. Biol.*, 100: 311--342.
[111]Walter, D.O. and Adey, W.R. (1966) "Linear and nonlinear mechanisms of brainwave generation." *Ann. N.Y. Acad. Sci.*, 128: 772--780.
[112]Namerow, N.S., Sclabassi, R.J. and Enns, N.F. (1974) "Somatosensory responses to stimulus trains: normative data." *Electroenceph. clin. Neurophysiol.*, 37:11--21.
[113]Gavalas, R.J., Walter, D.O., Hamer, J. and Adey, W.R. (1970) "Effects of low-level, low-frequency electric fields on EEG and behavior in *Macaca uemestriua*," *Brain Res.*, 18: 491--501.
[114]Goldman, J. "Sonic Entrainment". Spingte, Droh, Ed. *MusicMedicine*. MMB Music, Inc. St. Louis, 1992. 194-208.
[115]-McIntosh, G.C.; Thaut, M.H.; Rice, R.R. "Rhythmic Auditory Stimulation (RAS) as Entrainment and Therapy Technique in Gait of Stroke and Parkinson's Disease Patient's". *MusicMedicine 2*. MMB Music, Inc. St. Louis, 1996. 145-152.
-Safranek,M.; Koshland, G.; Raymond, G. "Effect of Auditory Rhythm on Muscle Activity". *Physical Therapy*, 62, 1982. 161-168.
-Thaut, M.H.; McIntosh, G.C.; Prassas, S.G.; Rice, R.R. "Effect of Rhythmic Cuing on Temporal Stride Parameters and EMG Patterns in Normal Gait". *Journal of Neurologic Rehabilitation*, 6, 1992. 185-190.
-Thaut, M.H.; McIntosh, G.C.; Prassas, S.G.; Rice, R.R. "Effect of Rhythmic Cuing on Temporal Stride Parameters and EMG Patterns in Hemiparetic Stroke Patients". *Journal of Neurologic Rehabilitation*, 7, 1993. 9-16.
-Thaut, M.H.; Schleiffers, S.; Davis, W. "Changes in EMG Patterns Under the Influence of Auditory Rhythm". Spingte, Droh, Ed. *MusicMedicine*. MMB Music, Inc. St. Louis, 1992. 80-101. McIntosh, et al. 1996)
[116]Condon, W.S. "Multiple Response to Sound in Dysfunctional Children". *Journal of Autism and Childhood Schizophrenia* 5:1, 1975. 43.

repetitive fashion. This differs from binaural beat stimulation, which will be detailed in upcoming paragraphs, where two distinctly different sounds are presented to each ear.

A. Monaural Beat Stimulation:

On the subjective front, monaural stimulation seems to be able to induce a wide variety of subjective states. For instance, there is new research suggesting that drumming can help treat a wide range of physical conditions, mental illnesses, and personality disorders.[117] In light of the biofeedback evidence for specific brainwave rhythms reflecting various disorders, and the success that they've had in changing those rhythms and relieving those disorders, evidence that drumming can relieve mental disorders should be evidence that monaural stimulation can alter brainwaves. In addition, monaural stimulation has been demonstrated to enhance hypnotic susceptibility,[118] increase relaxation, and induce shamanic-type states of consciousness,[119] claims also made about both binaural and photic stimulation. It is also asserted in several sources that the physiological, non-brainwave, and subjective reports of the effects of drumming typify altered states of consciousness, or NOSCs[120] and meditation.[121] Anthropologist, Dr. Michael Winkelman, out of Arizona State University, adds to this discussion in his

[117]Friedman R. Drumming for health. Percussive Notes. April 2001:55-57.
[118]-Maurer RL *et al*. "Phenomenological experience in response to monotonous drumming and hypnotizability." *Am J Clin Hypn*. 1997 Oct;40(2):130-45.
-Szabó, C. "The effects of monotonous drumming on subjective experiences." *Music Therapy Today* Vol. V (1) Jan. 2004
[119] Mandell A. Toward a psychobiology of transcendence: god in the brain. In: Davidson D, Davidson R, eds. The Psychobiology of Consciousness. New York, NY: Plenum Press; 1980:379-464.
[120]-Ibid.
-Winkelman M. Shamanism: The Neural Ecology of Consciousness and Healing. Westport, Conn: Bergin & Garvey; 2000.
-Winkelman M. Altered states of consciousness and religious behavior. In: Glazier S, ed. Anthropology of Religion: A Handbook of Method and Theory. Westport, Conn: Greenwood.
[121] Walton K, Levitsky D. A neuroendocrine mechanism for the reduction of drug use and addictions by transcendental meditation. In: O'Connell D, Alexander C, eds. Self-Recovery: Treating Addictions Using Transcendental Meditation and Maharishi Ayur-Veda. New York, NY: Haworth Press; 1994:89-117.

article "Complementary Therapy for Addiction: Drumming out Drugs"[122] when he notes the additional healing aspects of monaural stimulation:

> Physiological changes associated with ASC facilitate healing and psychological and physiological well-being through physiological relaxation; facilitating self-regulation of physiological processes; reducing tension, anxiety, and phobic reactions; manipulating psychosomatic effects; accessing unconscious information in visual symbolism and analogical representations; inducing interhemispheric fusion and synchronization; and facilitating cognitive--emotional integration and social bonding and affiliation.[123]

On the electromagnetic front, there is also some evidence that monaural simulation results in the driving of brainwaves. On the localized level, multiple EEG studies have confirmed that gamma waves can become entrained to auditory stimuli that are presented at rates in the gamma band (30-70Hz).[124] Some of these studies were not directed at understanding the human reaction to music, but rather at time perception[125] and human hearing.[126] The study on hearing also confirmed that beta frequency waves, as low as 12Hz, can become entrained at least for short periods of time. These studies were followed by an experiment on memory scanning processes that points to more evidence for conscious correlates of gamma oscillations. It demonstrated that gamma waves play a crucial role in memory scanning through the entrainment of the brainwaves of several subjects to clicks presented at various rates. They were able to show that the slower the click rate, the slower gamma waves pulsed, and the longer it took their subjects to complete their memory scanning task. Entrainment of brainwaves to the gamma

---

[122] Winkelman, M. "Complementary Therapy for Addiction: Drumming out Drugs." April 2003, *American Journal of Public Health*. Vol 93, No.4.
[123]Winkelman M. Shamanism: The Neural Ecology of Consciousness and Healing. Westport, Conn: Bergin & Garvey; 2000.
[124]Gerken, G. M., Moushegian, G., Stillman, R. D., & Rupert, A. L. (1975). "Human frequency-following responses to monaural and binaural stumuli." *Electroencephalography and Clinical Neurophysiology*, 38, 379-386.
[125] Triesman,M. et al. "The internal clock: electroencephalographic evidence for oscillatory processes underlying time perception." *Q. J. Exp. Psychol. A*. 1994, 47, 241–289
[126]Galambos R, Makeig S, Talmachoff PJ. "A 40-Hz auditory potential recorded from the human scalp." *Proc Natl Acad Sci US*. 1981 78:2643–2647.

frequency has also been used to assess aspects of the schizophrenic state of consciousness. A study on sensory processing showed that schizophrenics were very poor at entraining their brainwaves to gamma frequency auditory clicks compared to control subjects. This suggests that schizophrenics may be binding the features of objects differently than non-schizophrenics, which may account for some of their hallucinatory experiences.[127]

Entrainment of the alpha frequency to auditory stimuli in the alpha range has been confirmed by several studies of attention, and one study of responses to music. Ward discusses the findings on attention in his article on oscillating neural networks. He describes a model of oscillating attention put forth by Large and Jones that is based off of this work.[128] Ward writes:

> Attentional effort, or resource, is assumed to occur in oscillatory pulses, distributed in time by a simple phase oscillator whose period and phase can be entrained by rhythmical external stimuli such as music. When not entrained the phase and period drift around, possibly at an average frequency of ,0.5 to 2 Hz, and the focus widens. In the presence of external rhythmical stimuli, however, period and phase become entrained to the rhythm, and focus narrows to the emphasized points in time. The consequence of this focus on specific time points is that *stimuli that occur when expected are processed more effectively*, whereas those that occur at unexpected times suffer processing deficits.[129] Importantly, *under such conditions alpha oscillations are phase-locked to the occurrences of the entraining stimuli, even when they are omitted,*[130] indicating that attentional resources are being mustered for those specific processing moments [my emphasis].[131]

Entrainment to alpha frequency auditory stimulation has also been confirmed by a 1981

---

[127] -Kwon JS, *et al*. "Gamma frequency-range abnormalities to auditory stimulation in schizophrenia." *Arch Gen Psychiatry*. 1999 Nov;56(11):1001-5.
[128]Large, E.W. and Jones, M.R. (1999) "The dynamics of attending: how people track time-varying events." *Psychol. Rev.* 106, 119–159
[129]-Ibid.
- Barnes, R. and Jones, M.R. (2000) "Expectancy, attention and time." *Cogn. Psychol.* 41, 254–311
- Jones, M.R. et al. (2002) "Temporal aspects of stimulus-driven attending in dynamic arrays." *Psychol. Sci.* 13, 313–319.
[130]Maltseva, I. et al. (2000) Alpha oscillations as an indicator of dynamic memory operations: anticipation of omitted stimuli. *Int. J. Psychophysiol.* 36, 185–197
[131]Ward, pg. 557.

EEG study on complex rhythmic music in which the subjects listened to a Mozart symphony and chanting.[132] This was compared to their response to non-rhythmic conversation. The study reported increased alpha power during the rhythmic conditions, and synchronization of the EEG to the stimulus rhythm in the alpha range (around 10Hz). The study did not report any subjective effects of the stimulation.

Entrainment to stimulation in the theta range has been documented more extensively. Neher's 1961 paper on auditory driving reported changes in this range that have already been described. Neher's work was followed in 1994 by Maxfield, another researcher interested in shamanic trances, who confirmed that brainwaves can be driven by a monotonous drumbeat between in the range of 3 to 6 cycles per second (Hz). Maxfield also demonstrated that a variable rhythm can have a similar effect to a repetitive one. He played a simple variable rhythm at 4 beats-per-second and found that the same theta state was created as the non-varying 4 beats-per-second rhythm he had already tested.[133] This finding is intensely relevant given the nature of most music in the world, which has variation.[134] But it does not go so far as to say that constant variation has the same effect as none at all. It seems like Maxfield, in a sense, demonstrated what we all knew was true: that grooves- short repetitive phrases that are certainly more varied than shamanic drumming but not constantly varying- feel good. Incorporating variation into monaural stimulation also makes sense from an attention point of view: it is easier to keep your attention on something with more variety, which is more interesting. Maxfield

---

[132]Rogers LJ, Walter DO. "Methods for finding single generators, with application to auditory driving of the human EEG by complex stimuli." *J Neurosci Methods.* 1981 Oct;4(3):257-65.

[133]Maxfield, M. "The Journey of the Drum". *ReVision* Vol. 16, No.2, 1994. 157-163.

[134] Composite tempo is idea of tempo being created from a varied rhythm. If the main beat of a rhythmic figure is at 60 beats per minute (BPM) or 1Hz, the 16th notes of that phrase would be at 4Hz. Even if the 16th note rhythm was varied, it would comprise its own independent tempo, and could have entrainment effects. This becomes much more relevant during the discussion of chanting in the next chapter.

may be stepping in the direction of demonstrating why music in general has the structure it does, and even more relevantly, why we like it- why it does something for us at all. Researchers Wright[135], Winkelman[136], and Mandell[137] confirm the finding that theta frequency rhythms lead to theta frequency brainwaves, though they have not published studies in scientific journals on the subject.[138]

B. Binaural Beat Stimulation:

Additional support for the auditory brainwave entrainment hypothesis comes from studies on binaural beat stimulation, photic stimulation, and audio-visual stimulation. As I explained earlier, binaural beats (BB) are related to but not the same as monaural beats in that BB are presented to each ear independently, often through headphones, as opposed to monaural sounds that can be heard from one sound source. In practice, during my own listening sessions, monaural and binaural beats sound extremely similar. If I am correct that entrainment relies on attention, that the more attention one pays to a stimulus pulsing in time the more entrained you become (brainwave-wise and state of consciousness-wise) this form of stimulation should work in the same way as monaural stimulation. I am going to present a body of evidence that attests to the efficacy of specific tempos of binaural beats producing specific tempos of brainwaves in an effort to further substantiate that monaural beats work the way that the enormous body of subjective experiences and the existing lab research on them suggests.

[135]Wright P. "Rhythmic drumming in contemporary shamanism and its relationship to auditory driving and risk of seizure precipitation in epileptics." *Anthropol Consciousness.* 1991;2(3-4):7-14.
[136]Winkelman M. Shamanism: The Neural Ecology of Consciousness and Healing. Westport, Conn: Bergin & Garvey; 2000.
[137]Mandell A. Toward a psychobiology of transcendence: god in the brain. In: Davidson D, Davidson R, eds. The Psychobiology of Consciousness. New York, NY: Plenum Press; 1980:379-464.
[138] Winkelman, Michael. "Complementary Therapy for Addiction: 'Drumming Out Drugs.'" *Am J Public Health* 2003; 93: 647-651.

This form of stimulation has been used fairly extensively to induce a variety of states of consciousness, mostly in the commercial market, since the 1960s. Clinical studies on this stimulation are not in abundance, but there has been some work done in regards to the effects of these stimuli on relaxation, focus, attention, and states of consciousness.[139] In addition, and very significantly, binaural beats have been credibly documented to entrain brainwave rhythms, according to the frequency following response, at various sites in the brain.[140] These studies have not highlighted the subjective correlates of this entrainment, but have confirmed that entrainment is taking place. One of the reasons that more dramatic subjective experiences did not arise from this work is probably due to the fact that the beats they used were presented for very brief periods of time (under 90 seconds) in all cases. I'm going to present some of the more credible work in this area that confirms both that the subjective experiences associated with binaural beats are similar to those associated with monaural beats and that they seem to induce tempo-specific changes in brainwaves in the same manner as monaural stimulation.

Binaural beats:

> …Result from the interaction of two different auditory impulses, originating in opposite ears, below 1000 Hz and which differ in frequency between one and 30 Hz.[141] For example, if a pure tone of 400 Hz is presented to the right ear and a pure tone of 410 Hz is presented

---

[139]-Atwater, F. H. (1988). The Monroe Institute's Hemi- Sync process: A theoretical perspective. Faber, VA: Monroe Institute.
-Hutchison, M. (1986). Megabrain: New tools and techniques for brain growth and mind expansion. New York: Beech Tree Books.
-Monroe, R. (1982). The Hemi-Sync process. Monroe Institute Bulletin, #PR31380H. Nellysford, VA.
[140]-Dobie, R. A., & Norton, S. J. (1980). Binaural interaction in human auditory evoked potentials. Electroencephalography and Clinical Neurophysiology, 49, 303-313.
-Moushegian, G., Rupert, A. L., & Stillman, R. D. (1978). Evaluation of frequency-following potentials in man: Masking and clinical studies. Electroencephalography and Clinical Neurophysiology, 45, 711-718.
-Smith, J. C., Marsh, J. T., & Brown, W. S. (1975). Far-field recorded FFR's: Evidence for the locus of brainstem sources. Electroencephalography and Clinical Neurophysiology, 39, 465-472.
-Smith, J. C., Marsh, J. T., Greenberg, S., & Brown, W. S. (1978). Human auditory frequency-following responses to a missing fundamental. Science, 201, 639-641.
-Yamada, O., Yamane, H., & Kodera, K. (1977). Simultaneous recordings of the brain stem response and the frequency-following response to low-frequency tone. Electroencephalography and Clinical Neurophysiology, 43, 362-370.
[141] Oster, G. "Auditory beats in the brain." *Sci Am.* 1973 Oct;229(4):94-102.

> simultaneously to the left ear, an amplitude modulated standing wave of 10 Hz, the difference between the two tones, is experienced as the two wave forms mesh in and out of phase within the superior olivary nuclei. This binaural beat is not heard in the ordinary sense of the word (the human range of hearing is from 20-20,000 Hz). It is perceived as an auditory beat and theoretically can be used to entrain specific neural rhythms…Thus, it is theoretically possible to utilize a specific binaural-beat frequency as a consciousness management technique to entrain a specific cortical rhythm.[142]

The first organization to promote the use of binaural beat stimulation for consciousness expanding purposes was The Monroe Institute (TMI). TMI was founded in 1958 by Robert Monroe, a former radio DJ and station owner who began to have out of body experiences when listening to binaural beats he produced in his station.[143] These experiences led him to create the Hemi-Sync series of CDs and establish the Institute. TMI is self-described as: "An educational and research organization devoted to the premise that focused consciousness contains definitive solutions to the questions of human experience. Greater understanding of such consciousness can be achieved through coordinated research efforts using an interdisciplinary approach." TMI is now teamed with the Institute of Noetic Sciences in Petaluma, CA. and has been in operation for almost 50 years.

Two rigorous subjective studies confirm that the effects of binaural stimulation are extremely similar to those of monaural stimulation on states of consciousness: First, a study on attention, "Binaural Auditory Beats Affect Vigilance Performance and Mood" was published in Physiology & Behavior in 1998 by researchers from the departments of Psychiatry and Behavioral Sciences, at Duke University Medical Center, and was affiliated with the Center for the Study of Complementary and Alternative

---

[142] "The Science of Audio Based Brainwave Entrainment." http://webus.com/thescience.htm#What%20Is%20A%20Binaural%20Beat. Copyright 2003. 5/2/05.
[143] http://www.monroeinstitute.org/aboutus.html. 5/6/05.

Therapies, at the School of Nursing at the University of Virginia. In the study researchers presented a vigilance task to a group of subjects. The scientists played them beats from both the beta and theta/delta frequency ranges at different times and on different runs of the experiment. They report that:

> The results of this study provide evidence that presentation of simple binaural auditory beat stimuli during a 30-min vigilance task can affect both the task performance and the changes in mood associated with the task. The observed effects were consistent with our predictions regarding differential effects on alertness and mood. *Binaural beats in the beta EEG frequency range were associated with relative improvements in target detection and reduction in the number of false alarms compared to binaural beats in the theta/delta EEG frequency range. Moreover, beta binaural beats were associated with smaller increases in task-related confusion and fatigue compared to theta/delta beats.*[144]

With exposure to beta waves, waves associated with concentration and alertness (ref. Chapter 2), the subjects improved in their alertness and focus- they improved in their target detection and suffered less confusion and fatigue than when they were exposed to theta/delta range beats. The theta/delta range beats are in the sleep brainwave range. One would expect subjects to become more drowsy and less focused with exposure to these frequencies, and that is what they reported.

Second, "Peak and Other Exceptional Experiences During the Gateway Voyage," is a TMI 1996 subjective study of the effects of binaural stimulation that demonstrates the potential of this modality to induce non-ordinary states of consciousness. The Gateway Voyage is a 21 CD long self-administered course produced by the Monroe Institute designed to systematically to teach any individual how to alter their consciousness in a variety of specific ways. Participants consisted of volunteers from The Monroe Institute's Gateway Voyage program. Out of eleven groups, 160 people (81 males, 79

[144] James D. Lane et al. "Binaural Auditory Beats Affect Vigilance Performance and Mood." *Physiology & Behavior,* 1998 Vol. 63, No. 2, pp. 249-252.

females) participated. They ranged in age from 24 to 72, with a median age of 46.5. Out of 160 participants, 125 completed the study. Todd Masluk headed the study for the Institue and explains how they collected the subjective reports: "A two-part Peak-Experience Questionnaire (PEQ) was developed for this study. Part I was used to collect retrospective self-reports of participants' recent peak and other personally significant experiences. Part II was designed to explore the impact of these experiences on participants' lives, as well as the cognitive processes involved in integrating them." [145] One hundred twenty-one participants reported peak and other powerful or significant experiences on their PEQ. Of these 121 participants, 23 were single experiencers (i.e., reported only one experience) and 98 were multiple experiencers (they had two or more NOSC experiences). Twenty participants did not report any effects. Masluk asserts that, "Only two negative or "nadir" experiences were reported. The fact that only two nadir experiences were reported--out of a large pool of positive experiences--suggests that the Gateway program is overwhelmingly perceived as positive and growth-producing." [146] He concludes:

> Based on data collected from eleven groups, it appears that peak-experiences occur with regularity during the Gateway Program, as well as a wide range and multidimensionality of other trans-ordinary experiences. This great variety and depth of experiences suggest that Gateway helps to facilitate a huge opening or expansion of consciousness. This expansion seems to occur in both the outer and inner dimensions of being. Interestingly, the types, intensity, and richness of patterns of experience reported bear a striking resemblance to those reported by psychedelic (LSD) researchers.[147]

---

[145]Todd J. Masluk. http://www.monroeinstitute.org/voyagers/voyages/hsj-1996-spring-gateway-masluk.html.. 1996.
[146] Ibid.
[147]-Masters, R.E.L. & Houston, Jean (1966). *The varieties of psychedelic experience*. New York: Dell.
-Grof, S. (1976). Realms of the human unconscious: Observations from LSD research. New York: E.P. Dutton.
-Pahnke, W.N., & Richards, W.A. (1972). Implications of LSD and experimental mysticism. In C.T. Tart (Ed.), Altered states of consciousness (pp. 409-439). New York: Doubleday.

Both of the previous studies seem to adequately testify that binaural beats affect states of consciousness. As I demonstrated in Chapter 2, these effects could not have occurred without a dramatic shift in brainwave activity. Therefore, it seems that these subjective reports can used as evidence that brainwave shifts occurred systematically with the use of binaural stimulation. Further support for this claim comes from the following 3 EEG studies that document the ways that specific tempos of binaural beats induce specific tempos of brainwaves:

First, a study on binaural beats in 2003 was commissioned by Jacotte Chollet, a French musician and sound healer, who was interested in gathering some physiological data on the effects of her music on human brainwaves.[148] She creates a type of music called Multidimensional Music (MMD) utilizes binaural beat frequencies that are imbedded in ethereal synthesizer sounds, very much like the music coming out of TMI. Her study begins: "Very positive effects of MMD music have recently been measured and demonstrated at the Institute of Higher Nervous Activity & Neuro-physiology in Moscow by a member of the Russian Academy of Sciences, professor Dimitri Valouev, psychotherapist, psychologist, psychiatrist & narcologist at hospital n°17 in Moscow." For the study they used a 22-channel EEG, filtered for frequencies between 0 and 30 Hz. The study compared the effects of MMD music CDs on the brain with the brain state of human meditators without music. The results of study showed that MMD music stimulates theta waves as well as alpha waves that correlated with subjective reports of deep relaxation and deep meditation. The results also included reports of reductions in

[148] Jacotte Chollet. "Research 2003 in Moscow, Russia." http://www.multidimensionalmusic.com/research.htm#brainwaves. 3/17/04.

beta waves during alpha and theta conditions and increased beta power during in beta conditions.[149]

Second, an independent study out of the TMI, entitled, "The Effects of Hemi-Sync® on Electrocortical Activity: A Review of Three Empirical Studies"[150] reported significant effects with beta wave stimulation. The study was executed by M. R. Sadigh, PhD, director of psychology at The Gateway Institute (TGI), an affiliate program of TMI, and P. W. Kozicky, MD, founder and director of TGI. They studied the effects of beta frequency binaural beats on three individuals via EEG recordings, and reported consistently elevated beta-wave global brain synchrony in all three cases.

Third, a 1997 study out of Northern Arizona Univeristy, "Binaural-Beat Induced Theta EEG Activity and Hypnotic Susceptibility,"[151] reported that 5 out of 6 participants in the study showed an elevated presence of theta waves in their EEG and that according to the Stanford Hypnotic Susceptibility Scale demonstrated a higher degree of hypnotizability post-session in the medium and low hypnotizability groups (2 people in each group.)

If the argument holds that binaural stimulation is intimately related to monaural stimulation, though these studies are far from conclusive, they add to the evidence that tempo-specific stimulation has the effect I have described so far. Before I move onto describe the effects of photic stimulation, I'm going to share a piece written by a friend of mine, Megan Clark, who worked with me on a paper on auditory driving about a year ago. Her knowledge of human physiology came in extremely useful in this context, and she wrote up a short piece on how binaural stimulation may work on a

[149] Ibid.
[150] http://www.monroeinstitute.org/research/effects-of-hemi-sync-on-electrocortical-activity.html. 5/8/05.
[151] http://www.monroeinstitute.org/research/hypnotic.html. 5/8/05.

non-magnetic level. Her analysis seems to lend more credibility to the hypothesis that binaural beats have an intimate effect on consciousness:

"Before we review the literature supporting sonic entrainment, let us consider how this phenomenon could be physiologically possible. One plausible theory posited by The Monroe Institute is that "right and left auditory input is combined in the brainstem's superior olivary nucleus and routed to the reticular formation that, in turn, uses neurotransmitters to initiate changes in neurological activity in the thalamus and cortex."[152] Let us take this theory one step at a time.

When sound waves reach the cochlea in the inner ear, they are translated into electrical impulses by the hair cells, and these pulses travel along the auditory nerve into the brain. Each auditory nerve first travels to the cochlear nucleus on its own side of the brain. Each cochlear nucleus in turn projects to *both* superior olives, marking the first point at which sound input is integrated. From there, these integrated signals travel up through the reticular formation to the inferior colliculus of the midbrain and finally to the geniculate and auditory cortices of each hemisphere.[153]

The reticular formation is a critical step along the auditory pathway. Among its many functions, this neural network in the medulla and pons receives sensory information and relays it through the thalamus and forebrain to the cortex. The reticular formation has also been shown to play a critical role in states of arousal and attention. One part within this formation that is especially important is the pontomesencephalon, a structure strategically placed to regulate arousal. This structure receives sensory input and generates spontaneous neural activity. It then sends its axons to the thalamus and basal

[152] How Hemi-Sync Alters States of Consciousness. Monroe Institute Website. http://www.new-mind.com/MonroeInstitute/Hemi%20Sync%20brain%20wave%20patterns.htm. 3/14/04.
[153] Kalat, 192. See attached figure.

forebrain where it releases excitatory neurotransmitters. Those areas in turn relay arousal to widespread areas of the cortex.[154]

Many studies have shown the control that the pontomesencephalon exerts on arousal. A cut through this formation causes an animal to enter a prolonged state of sleep. Alternatively, stimulation of the pontomesencephalon awakens a sleeping person and shifts their slow sleeping brain waves into the beta range. This seems to be exactly what happens when we hear a loud sound and wake up; the mesencephalon receives auditory input and induces arousal.[155]

Another interesting finding relates to the effects of sleep deprivation on arousal and brain waves. Researchers found that during a prolonged period of REM sleep deprivation, an animal's reticular formation and the structures to which it projects (thalamus and cortex) will begin to produce brain waves in the lower alpha-theta-delta range, often in association with strange behaviors as if the animal were hallucinating.[156]

In summary, the reticular formation is just the sort of brain structure capable of integrating auditory input with arousal states. What would happen if we induced very rhythmic auditory signals? Researchers at the Monroe Institute theorize that such signals will entrain the neurons of the reticular formation which will in turn send similarly entrained signals up to the cortex inducing certain frequencies of brain waves. So in theory, if a person listens to a 7 Hz pulse for long enough, the reticular formation will entrain to this frequency, inducing 7 Hz brain waves, or those in the alpha range, and produce an alpha state of consciousness."

---

[154] Kalat, 274-275.
[155] Kalat, 274-275.
[156] Biopsych 278.

C. Rhythmic Photic Stimulation:

Research on rhythmic photic stimulation lends strong support to the hypothesis that brainwaves can become entrained by specific frequencies of external stimuli, and that entrainment can lead to various states of consciousness that depend on the duration of the stimulation, the cultural context, and the expectations of the person being stimulated. The effects of this form of stimulation have been documented via EEG recordings and subjective reports. Entrainment of brainwaves to photic stimuli has been reported by many studies, across the frequency bands gamma, beta, alpha, theta and delta.[157] Like the monaural and binaural studies, this experimentation with entrainment has mostly been limited to studies of durations that would be too short to see the symptoms of an NOSC come on, but there are several excellent examples of longer duration exposure to photic simulation that do indicate that NOSCs can be induced. First I will present evidence from subjective sources that testify to this end.

Thomas Budzynski explains in *The Clinical Guide to Sound and Light:*[158]

> In the 1930s and 40s scientists such as W. Gray Walter and others used powerful electronic strobe lights and the new EEG equipment to alter brainwave activity producing trance-like states of profound relaxation and vivid imagery. Hutchison[159] notes that Walter's research aroused the

[157] -Regan, D. (1966). "Some characteristics of average steady-state and transient responses evoked by modulated light." *Electroencephalography and Clinical Neurophysiology*, 20, 238-248.
-Nogawa, T., Katayama, K., Tabata, Y., & Ohshio, T. (1976). *Electroencephalography and Clinical Neurophysiology*, 40, 78-88.
-Yaguchi, K., & Iwahara, S. (1976). "Temporal sequence of frequency specific and nonspecific effects of flickering lights upon the occipital electrical activity in man." *Brain Research*, 107, 27-38.
-Aranibar, A., & Pfurtscheller, G. (1978). "On and off effects in the background EEG activity during one- second photic stimulation." *Electroencephalography and Clinical Neurophysiology*, 44, 307-316.
-San Martini P, Venturini R, Zapponi GA, Loizzo A. "Interaction between intermittent photic stimulation and auditory stimulation on the human EEG. Preliminary investigation through power spectral analysis." *Neuropsychobiology.* 1979;5(4):201-6
-Pollock VE, Volavka J, Gabrielli WF, Grings WW, Stern JA. "Brain responses to sine wave modulated light (SML): reliability and relationship to spontaneous EEG." *Int J Neurosci.* 1986 Jun;29(3-4):255-63.
-Isaichev SA, Derevyankin VT, Koptelov YuM, Sokolov EN. "Rhythmic alpha-activity generators in the human EEG." *Neurosci Behav Physiol.* 2001 Jan-Feb;31(1):49-53.
-Jin Y, Castellanos A, Solis ER, Potkin SG. "EEG resonant responses in schizophrenia: a photic driving study with improved harmonic resolution." Schizophr Res. 2000 Sep 1;44(3):213-20.
[158] Budzynski, Thomas. "The Clinical Guide to Sound and Light." <www.mindmodulations.com/ resources/Generalclinicalguide.pdf> 5/8/05.
[159] Hutchison, M. (1986). Megabrain. New York: Beech Tree Books. William Morrow.

> attention of a number of artists including the novelist William Burroughs. They developed a flicker device which they called the Dreammachine with which subjects reported dazzling lights of unearthly brilliance and color. From beautiful geometric images that resembled mandalas the display might dissolve into individual images and dramatic scenes like brightly colored dreams.

One of the first experimenters to pick up were Walters left off was Sidney Schneider, one of the first psychologists to introduce a commercial application of this technology. In1959, a year after Schnieder began using his photo device in his professional practice, he published a study in the Journal for Clinical and Experimental Hypnosis, in which he reported that he and his co-workers noted that over 90% of the approximately 2,500 subjects treated by 1959 had undergone light to deep hypnotic trance with the use of his device.[160] He also noted that as individuals became entrained they reported, "…A rainbow effect, fingers tingling, eyelids heavy, complete relaxation…a whirlpool effect, anesthesia, or dissociation…[they drifted] to the point of least resistance," –the point where it was possible to enter a trance state, assisted by audiotapes or a live hypnotic induction. At that same time, the editor of Hypnosis Quarterly attested to the rapid induction of deep trance in a previously unhypnotizable subject, using Schneider's device, to the depth of cataplexy (paralysis associated with certain trance states and REM sleep), analgesia and amnesia.[161] Other subjective evidence that photic entrainment induces NOSCs includes a 1959 report from the Journal of the American Medical Association that attested to the ability of photic stimulation to speed up hypnotic induction (likely by inducing theta waves) which was reported to "help make labor and delivery a more gratifying experience by reducing discomfort and the

[160]Kroger, W.S., and Schneider, S.A., "An Electric Acid for Hypnotic Induction," *J. Clin. And Exp. Hypn.*, April, 1959, pg. 93-98.
[161]Lewerenz, Carl T., "A Factual Report on the Brain Wave Synchronizer," *Hypnosis Quarterly*, Vol. VI, No. 4, 1963.

need for excessive analgesia and anesthesia."[162] There is also additional clinical and experimental testimony from this period that photic entrainment induces a hypnotic state[163] (to induce theta waves) and that it is useful to assist in the process of relaxation[164] (to induce alpha and theta waves).

The EEG evidence supporting these reported phenomena is strong, and comes from peer-reviewed journals. First, there is evidence from 18, 10, and 6Hz photic entrainment of NOSCs with brainwave driving at each frequency, with reports of visual and auditory experiences.[165] In addition, like monaural and binaural stimulation, there is evidence that photic entrainment induces state-experiences at various frequencies (ie. Alpha-state, theta-state, whole brain shifts in consciousness) from multiple sources.[166] In addition, there is EEG evidence that photic entrainment helped induce an alpha-state in a group of 20 meditators faster and more reliably than the group meditating without stimulation[167] and that it induced and alpha-state with hemispheric synchronization (indicating efficient processing[168]) in 7 out of 9 individuals in another study.[169]

In addition, a study on visual imagery and photic entrainment confirmed via EEG that 40 subjects entrained to 6, 10, and 18Hz, and reported that the most complex imagery was achieved in the 6Hz condition, with less in the 10Hz condition, and the least in the

---

[162]Letter to the Editor, "Hypnosis Machine," *Journal of the American Medical Association*, March 21st, 1959.
[163]-Phillips, Wm. A., "A Successful Technique for Hypnotic Induction of Resistant Patients," personal article, Hueytown, Alabama.
-Shealy, C Norman, "Brain Wave Synchronization (Photo-Stimulation) with the Shealy RelaxMate" presented at the meeting of the American Academy of Neuological and Orthopedic Surgery, December, 1990.
[164]Sadove, M.S., "Hypnosis in Anethesiology," *Ill. Med. J.*, July, 1963.
[165]Glickson, J., Department of Psychology, Tel Aviv University, "Photic Driving and Altered States of Consciousness: An Exploratory Study," *Imagination, Cognition and Personality*, vol. 6(2), 1986-87, pp 167-182.
[166]-Ronald, L., Luders, H., Klem, G., Dinner, D., Department of Neurology, Cleveland Clinic Foundation, "Visual Potentials Evoked by Light- Emitting Diodes Mounted in Goggles," *Cleveland Clinic Quarterly*, vol. 52, No. 2, Summer 1985, pp. 223-228.
-Takahashi, T., Tsukahara, Y., Department of Neuropsychiatry of Tohoku University School of Medicine, Tohoku, Japan, "Influence of Red Light and Pattern on Photic Driving;' *Tohoku Journal of Experimental Medicine*, 1979, 127, pp. 45-52.
[167]Williams, P., West, M., Department of Psychological Medicine, University Hospital of Wales and University of Wales Institute of Science and Technology, Cardiff, Wales, "EEG Responses to Photic Stimulation in Persons Experienced in Meditation," *Electroencephalography and Clinical Neurophysiology*, 1975, 39, pp 519-522.
[168] Ward, 2003.
[169]Inouye, T., Sumitsuji N., Matsumoto, K., Department of Neuropsychiatry, Osaka University Medical School, Japan, "EEG Changes Induced by Light Stimuli Modulated with the Subject's Alpha Rhythm," *Electroencephalography and Clinical Neurophysiology*, 1980, 49, pp 135-142.

18Hz condition, which gives further support both to the notion that entrainment of brainwaves occurs, and that that entrainment leads to tempo-specific states of consciousness that have particular attributes.[170] The 6Hz condition is a theta condition with complex mental imagery, supporting Chapter 1's claims that the theta state is a hypnogogic state of consciousness with rich access to emotions, memories, and mental images. Lastly, there is a credible photic entrainment study on using this technology to induce sleep, and to help insomniacs rest, which should certainly be the case if this technology can in fact induce various states, including sleep-states.[171]

Given the phenomenological relationships between the states of mind that are elicited by each of these forms of stimulation, it seems very likely that they all reflect similar changes in the rate of brainwaves in similar regions of the brain.

[170]Richardson, A., McAndrew, F., Department of Psychology, University of Western Australia, Nedlands, Australia, "The Effects of Photic Stimulation and Private Self-consciousness on the Complexity of Visual Imagination Imagery," in *British Journal of Psychology*, 1990, 81 pp. 381-394.
[171]Townsend, R., Neuropsychiatric Research, U.S. Naval Hospital in San Diego, "A Device for Generation and Presentation of Modulated Light Stimuli," *Electroencephalography and Clinical Neurophysiology*, 1973, 34, pp 97-99.

Chapter 5: Chanting

Before I go on, I'd like to clarify several aspects of the way I believe auditory driving works, if it is in fact doing what I think it's doing. First, when you hear a pulse in a certain frequency range, it has the potential to induce that frequency of pulses in your auditory cortex, which, if it goes on long enough, will lead to a shift in the functioning of the other neural networks in your brain, leading to an NOSC. Second, the more attention you pay to the stimulating pulses, the more quickly you will become entrained to them. Third, the process of entrainment is more like a slide, than a jump, frequency-wise. If you are wide awake, in a beta state, around 13Hz for example, and you start to hear a 4Hz pulse, you might become entrained to it, and start to move towards it, given that you pay enough attention to the sound. How much attention is "enough" I really don't know. But once entrainment began, you'd move down into 12, 11, 10, 9, 8Hz and so on until eventually your auditory cortex and the surrounding networks would reach 4Hz. The longer you listened to the frequency (the more repetitions of the chant, mantra, drumming etc. you heard), the more likely it would be that you would actually reach 4Hz, and again, the more attention you paid to the sound, the more quickly that shift would take place. This specific aspect of attention, that the longer and more intensely someone pays attention to a stimulus the more entrained they will become, is suggested by Galbrath's study on attention and the frequency following response.[172] Once your brainwaves have shifted, you will begin to experience an alerted state of consciousness, or an NOSC. You

[172] Galbraith GC, Olfman DM, Huffman TM. "Selective attention affects human brain stem frequency-following response." *Neuroreport*. 2003 Apr 15;14(5):735-8.

might notice this as soon as your brainwaves start to shift, or it might take longer to be pronounced.

So just to be clear, when the meditators, trancers, and other practitioners I'm about to discuss do their chanting, drumming, and prayer at the auditory frequencies I'm going to highlight, I believe that they move towards the brainwave frequencies that parallel the auditory frequencies they are hearing, but don't necessarily get there every time they chant and meditate. If they're distracted, if they're upset, feeling hyperactive, or too tired, entrainment probably won't take place very intensely. And in addition, once entrainment does take place, the setting you are in can either reinforce your trance, or pull you out of it, depending on how it affects your state of attention. Without a doubt, there are many factors that can limit the effectiveness of auditory driving. But with adequate attention, and repetition, it seems that this modality can be a tremendously powerful tool to enter an NOSC. More specifically, chanting, mantra recitation, and ritual drumming are all technologies that seem to help with the superposition of states of consciousness, or types of focus, onto one another. None of the actual ritual actions or meditations I've studied are totally linear, in the sense of someone being stimulated in only one way. This is true in the sense that if you are focusing on a mantra, you are also focusing on your breath. Your concentration on the mantra would keep you awake, while the repetition of it would slowly bring you towards sleep. With practice, you would learn to stay awake as this falling asleep process goes on- via your concentration on your breath, that is likely producing beta waves, as your mantra produces theta waves. Or with drumming—dancing and moving to the drumming would constantly be stimulating you as the

drumming itself caused other parts of your brain to begin to enter a mode like sleep. The two states superimposed onto one another could lead to trance.

A survey of Buddhist chants supports my argument for auditory driving because it turns out that the tempos that people are chanting at are extremely consistent across various countries and traditions. And relevantly, when there were descriptions of the chants in the CD notes that were available, the phenomenological descriptions of the states that were being sought after in each chant meditation seemed to correlate with the state of consciousness that each chanted tempo should produce, according to the framework established during the discussion of rhythmic frequencies and their associated states of consciousness in Chapter 2. To research for this chapter, I collected an assortment of CDs of Buddhist chanting- the search was mostly limited by the selections the Stanford Music Library had to offer. I went on the Internet, but sources were slim. I ended up listening to anything on the CDs I collected that was called a "chant," ignored hymns, and listened to the few prayers that were available. Many of the elements of the chanting that I am going to focus on here are relevant to and shared by many other religious traditions throughout the world, both in their forms of chanting and also in any use of mantras and prayers that take on a similarly repetitive and rhythmic form.

I'm going to start this section with a discussion of chanting performed to a regular, constant rhythm and explore the different ways rhythms are subdivided to produce different entrainment effects. Next I'm going to look at slow chants that lack a strong central pulse, and discuss the use of vibrato and its possible impact on one's brainwaves. I'm going to follow that with a discussion of group chanting and the effects

that it may have on the brain and, lastly, I'll discuss throat singing and the psychological effects it seems to help produce.

The first category of chanting I'd like to highlight covers chanting performed at an even tempo. Most of the chants I came across in this category emphasize pulses between 2Hz and 8Hz. Depending on the chant, these tempos are either achieved with the syllables of the chant falling on the beat, or subdividing it. In other cases, the melody line subdivides the rhythm, creating a faster tempo for a short period of time. I came across several examples of chanting with syllables falling only on the strong beats, among a variety of Buddhist traditions. The second CD of *Anthology of World Music, The Music of Tibetan Buddhism*[173] is a good place to begin. *Track 1, "History of the Sakya religion," features chanting at a constant pitch, with the syllables of each word falling on the main 6Hz beat. Chanting at this tempo falls into a high theta range. This particular track fades out after 2:30 seconds, but if this chant went on for long enough, it would eventually induce a very relaxed state that would resemble being on the verge of dreaming. Track 4, "An offering (to the god of) Sakya (through) chanting and instrumental music", highlights a slower chant at 2Hz. This chant is very rhythmical, accompanied by a drum. The drum beats at 1Hz, and the chanting syllables fall twice as fast as the drumbeat, at 2 Hz. A chant that is this slow, but rhythmical, would probably put most laymen to sleep, as it would induce delta waves, which accompany deep sleep. An experienced meditator, on the other hand, could use a chant at this tempo to achieve a state of conscious stillness. *Track 8, "Prayer for the Dalai Lama," is chanted at 6Hz and moves between a swung, or loping, and straight feel. Swinging the rhythm in this way, like they do in jazz music, would actually probably be less consciousness-shifting than a

[173] *Anthology of World Music, The Music of Tibetan Buddhism.* Disc 2. Rounder CD: Rounder Records Corp. Copyright 1999.

straighter beat. Because our brainwaves pulse with extreme regularity, the loping rhythm would likely make entraining more difficult. This might serve a helpful purpose in keeping the meditator more alert, preventing sleep, while still inducing calming, mind-clearing effects.

*Track 9, "Doctrine concerning the afterlife," introduces a new subtlety to the rhythmic chant category. This chant uses 3 pitches, instead of the single pitch the previous chants utilized, and the main pulse of the syllables is at 3Hz. In this example, the beat is divided both syllabically, and melodically, to achieve a 6Hz pulse. Within each line, there are groups of syllables that fall twice as fast as the main syllables, subdividing 3Hz to produce a 6Hz rhythm. In addition, the chanter uses the 3 pitches of the chant to vary the melody as the syllables pass by. He often sings rhythms within the melody that do not have syllables associated with them. In other words, he lands on a syllable and in the time in which the syllable is sung he changes between two notes, producing an extra beat, or a 6Hz rhythm over the 3Hz rhythm. A similar example of melodic variation is located on *Anthology of World Music, The Music of Vietnam*[174]. On the first disc of this 2 CD set, *track 7, "Recitation of Buddhist prayers," has the main beat at about 1Hz. The syllables fall at 2Hz, and the melody subdivides the syllables into a 4Hz beat. This particular track gets faster as it goes on. By minute 2:30 they've sped the main beat up to 1.5Hz, leaving the syllables at 3Hz and the melody at 6Hz. These frequencies would produce a theta state- a very receptive, suggestible state that could cause the prayers to resonate more emotionally with the meditators and be remembered better than if that state had not been induced.

[174] *Anthology of World Music, The Music of Vietnam*. Rounder CD: Rounder Records Corp. Copyright 1999.

Several other chants I came across also follow this constant-rhythm model.[175] It should be noted that in many of the examples involving constant rhythm, instrumental accompaniment is used, either in the form of a singing bowl, bell, or woodblock. I think it is likely that these instruments are used for the explicit purpose of keeping the chanting in rhythm. These instruments usually mark the strong beat in the chant, with the syllables subdividing it. I found several good examples of this type of chant at buddhanet.net. A Sino-Vietnamese chant, *"The Early Morning Great Bell Verse," has three sections, slow to begin, around 2Hz, fast in the middle, about 4Hz, and then medium tempo to end, at 3Hz. A Thai chant I came across, called, "The Karaniya Metta Sutta," is performed at 5Hz. And lastly there is a similar recording called, "Dhammacakkappavattana Sutta (The Buddha's First Sermon)" in which Thai monks chant at an even 3Hz.

Another large category of chants follows a form very similar to the slow, meditative alaps of the Indian classical music tradition. *Drops of Emptiness,*[176] disc 1, largely follows this form. In particular, track 1, "Inviting the Bell," sounds just like an alap. It's very slow and "meditative," in the colloquial sense, with no distinct central beat. *Track 2, "Prelude to Sitting Meditation" follows the same form. Each word is held for about 10 seconds and the chanter hits a singing bowl in between the phrases. At first as I listened to these selections, I couldn't perceive any relationship between the long drawn out notes and my understanding of entrainment. After about a half hour, I realized that I'd been ignoring the vibrato that was present on every one of these recordings. Of

[175] Vietchant01.mp3., "The Early Morning Great Bell Verse," Karaniya Metta Sutta, Dhammachakka.mp3, "Dhammacakkappavattana Sutta (The Buddha's First Sermon)." <http://www.buddhanet.net/audio-chant.htm> Buddha Dharma Education Association, Copyright 2004. 12/2/04.

[176] *Drops of Emptiness: Songs, Chants, and Poetry from Plum Village*. Sounds True: Sounds True. Copyright 1997.

these examples, a couple stand out. On the album, *One Sound*,[177] *track 1, "Morning bell chant," a singing bowl is struck periodically as the chanting goes on. It produces a standing wave at 6Hz, which increases in volume each time the bowl is struck. The chanting on the track is not regular in rhythm, and suggests no main pulse. The interesting thing is that when the chanter sings vibrato, which he does whenever he holds a note for more than a couple of seconds, the beating of his vibrato it is right at 6Hz. He's clearly mimicking the sound of the bowl and it is keeping his vibrato in rhythm.

This observation reminded me of a comment a friend made in an Indian music class I took last quarter. She told us about how the moments during bhajans, devotional hymns, that involve quick gamak vibrato, with pitch slides from low to high, are the moments when singers report feelings of ecstasy that last only for the duration of that particular vocal inflection. This has a strong parallel with the brief entrainment reported in a variety of the sources I discussed earlier. Neher reported subjects entraining to 40 second bursts of pulses, and I have read several other papers that report entrainment to as few as 5 clicks heard in rapid succession.[178] This seems to suggest that when those brief but rapid vibrato passages are repeated over and over again, as they are in a chanted context, they can be catalysts for deep, seemingly spontaneous meditation. An additional audio example of this use of vibrato can be found in the Vietnamese Buddhist chanting of

[177] *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan*. Ellipsis Arts…: Ellipsis Arts… Copyright 2000.

[178] -Ross B, Borgmann C, Draganova R, Roberts LE, Pantev C., "A high-precision magnetoencephalographic study of human auditory steady-state responses to amplitude-modulated tones." *J Acoust Soc Am*. 2000 Aug;108(2):679-91.
-Makela JP, Hari R. "Evidence for cortical origin of the 40 Hz auditory evoked response in man." *Electroencephalogr Clin Neurophysiol*. 1987 Jun;66(6):539-46.
-Neher A. 1961.
-Goldman, D. "The effect of rhythmic auditory stimulation on the human EEG." *Electroenceph. clin. Neurophysiol*., 1952, 4: 370.
-Chatrain, G. E., Peterson, M. C. And Lazarte, J. A. "Responses to clicks from the human brain: some depth electrographic observations." *Electroenceph. clin. Neuropbysiol*., 1960, 12: 479-489.
-Gastaut, H., Roger, J., Corriol, J. And Gastaut, Y. "Epilepsy induced by rhythmic, intermittent, auditory stimulation or epilepsy "psophognique"." *Electroenceph, clin. Neurophysiol*., 1949, 1: 121.,
-O'flanagan, P. M. And Gibson, H. S. "Activation of the EEG by auditory stimulation combined with Metrazol." *Electroenceph. clin. Neurophysiol*., 1951, 3:505-509.
-Sem-Jacobsen, C. W., Peterson, M. C., Dodge, H. W. Jr., Lazarte, J. A. And Holman, C. B. "Electroencephalic rhythms from the depths of the parietal, occipital, and temporal lobes in man." *Electroeneeph. clin. Neurophysiol*., 1956, 8: 263-278.

"The Prayer for Harmony and Peace"[179] in which the chanter sings very slowly, using vibrato at about 6Hz. One last example comes from *Anthology of World Music, The Music of Vietnam,*[180] disc 1. *Track 8, "Buddhist Chant", actually has a very slow main beat, at about 2Hz, but the chanter sings vibrato consistently at 8Hz throughout the piece.

Another way to achieve a meditative effect with chanting can come out of a group session. First, simply having other people around you chanting allows you to relax and enter into the experience, because you don't have to do all the work of keeping the chant going yourself. Second, when people chant in groups, they tend to be more in rhythm than if they are chanting alone. This is a form of entrainment. It is easier for your body to react in a complementary way to an outside stimulus than it is to fight it. If someone is chanting a rhythm right next to you, you aren't going to try to maintain your own pulse, you'll lock into their rhythm and they'll lock into yours, making both of your experiences of that rhythm stronger. It's much easier to work with their rhythm than it is to fight it.

A third factor at play in group chanting, that I'd like to highlight here with a few more examples, is dissonance. As hard as people might try to lock in, and as natural as it is, it never works perfectly, and when you sing in a chorus there are always people that are out of tune. And when you're not way out of tune, but pretty close to the right pitch, an interesting auditory phenomenon takes place. You end up hearing the difference between the two tones. For instance, when you tune a guitar and you almost get one string at the pitch of the other one, you start to hear a beating in the pitch of the two strings. It is usually fairly slow, and you know you're in tune when it goes away. This is called a beat frequency, or a difference tone. Beat frequencies occur when two pitches

[179] Vietchant02.mp3. "The Prayer for Harmony and Peace." <http://www.buddhanet.net/audio-chant.htm> Buddha Dharma Education Association, Copyright 2004. 12/2/04.
[180] *Anthology of World Music, The Music of Vietnam*. Rounder CD: Rounder Records Corp. Copyright 1999.

are slightly different from one another. Mathematically, if one person is singing at 200Hz, and another person starts singing along a little bit sharp, that sharp pitch could be at 205Hz. When those two people stand next to each other and sing together, on top of the 200Hz and 205Hz, they'll also both hear a 5Hz difference tone pulsing at 200Hz.

It's interesting because even when a group is out of tune, it actually might sound good to a listener. The listener often perceives difference tones as "texture," something that adds to the overall timbre of the chorus. There's even a technique that modern recording studios use to record vocals called "molting." They have a singer sing their part, and then they record it over again several more times, and layer those parts on top of each other. Each time the singer sings a take, they sing it slightly differently, which results in an abundance of difference tones when all the takes are layered on top of each other. They do this to make the singer's voice sound more "natural" and less "digital."

These difference tones usually fall in the same range of pulses that we've been discussing this whole time, somewhere between 2 and 8Hz. According to the entrainment theory, these tones should produce a relaxed state in the listener (and singer), if they listen for long enough, with enough attention. *Track 6, "Hyakuhachisan" from *One Sound*[181] is an especially exaggerated example of this. It's exaggerated because it is a recording of a group singing in unison, while attempting many difficult pitch bends throughout the song. It has a very thick sound to it, which comes from some dissonance in the chorus. The music is beautiful, and very entrancing. The liner notes read: "…Shomyo chanting has been strictly passed down from master to disciple through established theory…the meaning of Shomyo was used to describe only music concerned

[181] *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan*. Ellipsis Arts…: Ellipsis Arts… Copyright 2000.

with vocalization and rising and falling of tones. It is considered the most sonorous style of chant."[182] Other examples include the *Chanting of Nichiren Buddhism*, titled "Nam-Myoho-Renge-Kyo"[183], which has a similar sound to "Hyakuhachisan," but is chanted regularly at 4Hz. A variation on the same tune[184], also chanted in a group, starts at 3Hz, with 6Hz syllable subdivisions, and slows down as the chant goes on (2/3 way through) to about 2Hz with 4Hz syllable subdivisions.

The last category of chants that I would like to discuss pertains to chanting at very low pitches. Tibetan throat singing is the most outstanding form of this chanting, but much of the chanting I listened to utilized low pitches as well. Chanting using mostly low notes should be more advantageous to induce a meditative state than high pitches because of the Steady-State Response (SSR). The SSR is a response that your brain has to 40Hz pulses. 40Hz seems to be the easiest pitch to entrain to. The farther a pitch is from 40Hz, the more difficult it is to entrain to it. This is especially interesting in light of a study I read recently on gamma frequency brainwaves that I discussed briefly at the beginning of this paper. The study is called, "Long-term meditators self-induce high-amplitude gamma synchrony during mental practice"[185] and it emphasizes that practiced meditators, who meditate on emotion (compassion) without placing their attention on any particular object, seem to produce many more brainwaves in a band between 25 and 42Hz than control subjects. This means that promoting gamma activity allows the meditator to focus more completely on a particular emotion than when gamma activity is suppressed, as in the case of the control subjects who haven't cultivated this ability.

---

[182] Morris, P. *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan booklet.* Ellipsis Arts…: Ellipsis Arts… Copyright 2000. Pg. 52.
[183] Nam_myoho.mp3. "Nam-Myoho-Renge-Kyo." <http://www.buddhanet.net/audio-chant.htm> Buddha Dharma Education Association, Copyright 2004. 12/2/04.
[184] Nichiren_gong.mp3. "Nam Myoho Renge Kyo/Recitation of 2nd/16th chap. Lotus Sutra." <http://www.buddhanet.net/audio-chant.htm> Buddha Dharma Education Association, Copyright 2004. 12/2/04.
[185] Lutz , 2004.

Refer back to the section on gamma (Chapter 2) for a more complete discussion of this phenomenon.

Chanting at very low frequencies, between 40 and 80Hz, like the throat singers do, should certainly cause entrainment to those frequencies. It very likely allows them to integrate information more effectively and experience whatever they are experiencing more fully. One interesting aspect of the throat singing in particular is that, like some previous examples, there is a rhythm amid the drones they sing. *Track 5, "Mandel Tachen (Great Melody Mandala Offering),"[186] on *One Sound* is a great example. In this track the first thing you hear is the deep drone of the throat singing. But as you listen, you can start to notice that there are pulses in the form of a sort of vibrato within the drone. In this case, the pulses are right at 4Hz. This means, potentially, that the monks are superimposing two different brainwave responses onto each other. There is the intense relaxation and imagination-inducing (hypnogogic) property of the 4Hz, but there is also the low drone somewhere between 40 and 80Hz. That drone is likely causing the kind of brain-wide information integration that I just described. This should produce a combined state of deep relaxation and clear focus. The booklet for the CD reads:

> "This prayer is performed by monks of Loseling Dratsang of Drepung Monastery during the Monlam Chenmo, the Great Prayer Festival of the Tibetan New Year. In the mandala offering, a lama holds up a tray and pours onto it precious substances in a specific pattern. This prayer, sung at the time of the mandala offering, visualizes the universe transformed into a Buddha-field, which is then offered to the teachers and enlightened masters as a petition so that all beings may enjoy universal peace and happiness."[187]

---

[186] *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan*. Ellipsis Arts…: Ellipsis Arts… Copyright 2000.
[187] Morris, P. *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan booklet*. Ellipsis Arts…:Ellipsis Arts…Copyright 2000. Pg. 51

This difficult visualization meditation seems like it would be nicely complemented by the state of consciousness that would be produced by this particular mode of sonic stimulation. They need dramatic access to their imagination in order to vividly visualize the universe as a Buddha-field, which is likely supplemented by potent memories of their past visualization experiences, along with intense concentration and clarity in order to hold it all together, all of which seems to be reinforced by the way they are chanting.

*Track 1, "Yamantaka," off of *The Gyuto Monks: Freedom Chants From The Roof of the World*[188] is very similar to the track previously mentioned and seems to be used for a very similar purpose. It is another example of throat singing, except this time there is more of an established beat to the drone. This beat is at about 1.5Hz but in this case there are tonal subdivisions producing a 3Hz pulse. The description of the meditation goes as follows:

> "During this contemplative recitation, the monks identify themselves with the divine Buddha form Yamantaka ("Terminator of Death"). In focused visualization, they enter his sacred Mandala palace, where they become channels for Yamantaka's stream of life-giving blessings to all beings. Although Yamantaka manifests a teriffic, triumphal appearance, this Buddha form is actually the gentle Bodhisattva Manjurshri, archangel of selfless wisdom."

The emphasis on clarity and visualization is extremely similar, and the low drone with the imbedded pulses is too.

I will discuss more about what I think all of this adds up to in the conclusion to this paper. For now, I'd like to point out that there are many other rituals that follow this same model. The following chapter will discuss the use of several instruments that seem

[188] *The Gyuto Monks: Freedom Chants From The Roof of the World*. Rykodisc: 360 Degree Productions. Copyright 1989.

to be built to entrain human beings, and will briefly cover a couple of mantra and prayer examples to tie their form into this discussion.

Chapter 6: Ritual Instruments and Other Stimulation Techniques

As long as people have been playing instruments they have been using them to alter their states of consciousness in a variety of different ways. From shamans worldwide beating their drums and going on metaphysical journeys, to Tibetan Buddhists with their singing bowls, bells, and damarus entering into meditative states, to meditators worldwide using chants, mantras and prayers to deepen their focus, auditory driving seems to be the common thread. The following will be a brief analysis of each of these phenomena in an effort to demonstrate their commonalities.

A. Shamanism:

The Romanian American historian of religions, Mircea Eliade, wrote Shamanism: Arcahic Techniques of Ecstasy, the Western masterwork on shamans and shamanism. He incorporated a wide variety of tribal variations of shamanic practices into a unified concept of the shaman, terming them "technicians of ecstasy."[189] According to Eliade, "The shaman specializes in a trance during which his soul is believed to leave his body and ascend to the sky or descend to the underworld."[190] Historically, shamans have been just about everywhere- in Central, North, South and Southeast Asia, North and South America, in Oceania, Tibet, China, and the Far East, in Africa, and throughout the Middle East and Europe.[191] Shamanic practice fits squarely into the model of auditory driving that I've established so far, and it is a good place to begin a look at the use of instruments to induce brainwave entrainment. Leo Rutherford writes in his book Principles of

[189]Eliade, Mircea. Shamanism: Arcahic Techniques of Ecstasy. (Princeton Univeristy Press: Princeton) Copyright 1964. pg. 5.
[190] Ibid.
[191] Eliade, 1964. [Reference: Table of Contents]

Shamanism, "The drum is the most important tool in the shaman's armory. Many consider the drum the single most consciousness-moving, healing artifact in human life. Our consciousness responds to rhythm and sound and is deeply affected by it."[192] Michael Harner, in his work, The Way of the Shaman, emphasizes the effects drumming has on the psyche: "The use of the drum to initiate trance states has been utilized world-wide. Although not every culture uses a drum to enter these altered states of consciousness, many utilize some form of repetitive 'noise.'"[193]

In Mickey Hart's autobiography and exploration into the world of ethnomusicology, Drumming at the Edge of Magic, he reflects on shamanic drumming: "Statements like 'the shaman rides his drum like a horse' seemed to me to be a way of saying that 'the shaman entrains with the rhythm of the drum and it carries him deeper into trance.'"[194] He also notes that, "The shamanic ritual, held in a small, enclosed space, seems designed to enhance these percussive effects." In terms of grabbing the attention of the shaman and holding it, the resonance of this ritual space is probably not trivial. Harner's version complements Mickey's: "The repetitive sound of the drum is usually fundamental to undertaking shamanic tasks in the SSC [Shamanic State of Consciousness, Harner's term for an ecstatic trance state]. The steady, monotonous beat of the drum acts like a carrier wave [or a horse], first to help the shaman enter the SSC, then to sustain him on his journey." As Harner suggests, the drumming keeps the shaman in his trance as well as bringing him there. There is often an assistant to the shaman who will immediately take over the drumming once the shaman's trance has gotten so deep

[192] Rutherford, Leo. Principles of Shamanism. (Harper Collins Publishers: New York), 1997. pg. 102.
[193] Harner, Michael. The Way of the Shaman, (Harper Collins Publishers: San Francisco) Copyright 1990. pg. 72.
[194] Hart, Mickey. Drumming at the Edge of Magic. (Harper Collins Publishers: New York) Copyright 1990. pg. 176.

that he can no longer continue playing himself.[195]

According to Winkelman, a cross-cultural survey of 47 societies confirmed that at least one shamanic practitioner from each community engaged in induction of an NOSC.[196] Harner[197] and Krippner[198] both report that 3-6 cycles per second are rhythms associated with many shamanic rituals and Winkelman confirms that these rhythms produce a theta-state in the shamans: "This mode reflects slow wave discharges, producing strongly coherent brain wave patterns that synchronize the frontal areas of the brain, integrating nonverbal information into the frontal cortex and producing visionary experiences and insight."[199]

Krippner offers an interesting analysis of shamanic behavior that complements much of the discussion of NOSCs and attention that has threaded through this entire thesis:

> It may be more appropriate to speak of *shamanic modification of attentional states* rather than of a single *shamanic state of consciousness* (such as soul flight). Attention determines what enters someone's awareness. When attention is selective, there is an aroused internal state that makes some stimuli more relevant than others and thus more likely to attract one's attention. More basic to shamanism may be a unique attention that they give to the relations among human beings, their own bodies, and the natural world—and the shamans' willingness to share the resulting knowledge with others.[200] The suppression of seances, spirit dances, and drumming rituals by colonial governments and missionaries led to the decline of altered states induction in some parts of the world.[201] The function of these procedures had been to shift the shaman's attention to internal processes or external perceptions that could be used for the benefit

---

[195] ***Hart, 1990. pg. 176?
[196] Winkelman, 1992.
[197] Harner, 1990.
[198]Krippner SC. "Conflicting perspectives on shamans and shamanism: points and counterpoints." *Am Psychol*. 2002 Nov;57(11):962-78.
[199]Winkelman, 2000.
[200]Perrin, M. (1992). The body of the Guajiro shaman: Symptoms or symbols? In E. J. M. Langdon & G. Baer (Eds.), *Portals of power: Shamanism in South America* (pp. 103–125). Albuquerque: University of New Mexico Press. Pg. 122-123.
[201] Hugh-Jones, S. (1996). "Shamans, prophets, priests and pastors." In N. Thomas & C. Humphrey (Eds.), "Shamanism, history, and the state" (pp. 32–75). Ann Arbor: University of Michigan Press. Pg. 70.
-Taussig, M. "Shamanism, colonialism, and the wild man: A study in terror and healing." Chicago: University of Chicago Press. 1987. pg. 93-104.

> of the community and its members. Outsiders' bans of these technologies diminished the social role played by shamans and increased tribal dependence on the colonial administrators.[202]

B. Tibetan Buddhism and Mantras:

Tibetan Buddhists have their own arsenal of consciousness altering devices. The Bon religion, which was present in Tibet before Buddhism arrived and is related to modern-day Tibetan Buddhism, was a shamanic religion. Their rituals reflect this legacy in their continued use of sound to alter consciousness. Since Bon, Tibetans have developed several ritual instruments that utilize repetitive beats. These various instruments are played during prayer rituals and at other times to help the monks enter, deepen, and sustain their meditative states. I'd like to begin with a discussion of Tibetan bells. Jonathan Goldman, a lecturer for the International Society for Music and Medicine, has studied with the Dalai Lama's Chanting Gyuto and Gyume Monks and is the creator and head of The Sound Healers Association. He explains that:

> Tibetan bells, or Ting-Sha's, have been utilized in Buddhist meditation practice for many centuries. An examination reveals that the two bells, which are rung together, are slightly out of tune with each other. Depending upon the bells, the difference tones between them create ELFs [Extremely Low Frequencies] somewhere between 4 and 8 cycles per second. This falls exactly within the range of the brain waves created during meditation and helps shift the brain to these frequencies.[203]

The ELFs make a wah-wah sort of sound that continues until one of the bells stops vibrating. Tibetan singing bowls produce a similar effect. When you create friction by dragging a wooden stick around the rim of the bowl, it begins to create a sustained tone, made up of many different pitches. The dominant sound coming from the bowl, other than the sustained ethereal drone, is a wah-wah beating sound that comes from the

[202]Krippner, 2002. pg. 967.
[203] Jonathan Goldman. "Sonic Entrainment. " http://www.healingsounds.com/articles/sonic-entrainment.asp. 3/17/04.

interaction of the pitches. This pulsing remains at a constant tempo as long as the bowl is vibrating at an even rate. A beating sound can also be produced from the bowl by striking it on its side and allowing it to ring.

The last Tibetan instrument I'd like to highlight is the damaru, a two-headed hand-held drum. It has two beads attached to two strings connected to the opposite sides of the body of the drum. When it's rotated, you can easily produce an even beat at a fairly quick tempo with only one hand. Lamas utilize these drums in various meditative settings. In a striking account in Drumming at the Edge of Magic, Hart describes what happened during his encounter with a damaru:

> "I played it for 10 or 15 more minutes before putting it away. It was fun to look at and would be fun to tell stories about, but I never expected to play it again. I set it back on the shelf and then went and threw up…I had no reason to associate my nausea with the damaru. But I soon began bumping into things, falling down when I shouldn't have, injuring myself in minor but annoying ways."[204]

This seems to be an account of a mild trance induced through the playing of the damaru. Like the singing bowl and the bells, this instrument, with its even rhythmic pulses, also follows the model of auditory driving I've proposed.

The use of mantras to induce meditative states is another example of auditory driving in action. Though there's no external instrument involved, repeating a mantra to oneself can provide a strong auditory stimulus that can achieve a similar end to a repetitive instrumental sound. In this context, a mantra is any string of words that is repeated over and over again with the intention of inducing a meditative state. In lab studies mantra recitation has been shown to reduce anxiety levels and increase alpha

[204] Hart, 1990. pg. 180.

power,[205] induce relaxation[206] and lower blood pressure,[207] and induce theta and delta waves (sleep).[208] It has also been shown in a study comparing recitation of the Ave Maria prayer to the yogic mantra "Om Mani Padme Hum" that both equally slowed respiration and "caused striking, powerful, and synchronous increases in existing cardiovascular rhythms."[209]

Usually the mantra holds some special significance for the meditator- which would be crucial if one's attention was going to actually remain on it. They are often used in sitting meditation. In a generic example, the meditator would try to slow his thoughts and focus his mind by paying attention to the flow of his mantra. Repeating the mantra would help the meditator focus inward, suppressing external stimulation, and would eventually lead to an NOSC. This would aid the meditator in any visualization regime that was combined with the mantra recitation and could also lead to intensified focus. When repeated out loud or in one's head mantra syllables create a regular rhythm that seems to help practitioners focus and maintain desired states of consciousness. A contextual aspect of this type of stimulation that is worth mentioning is that mantras often function as hypnotic suggestions that are repeated over and over again, becoming more potent as a suggestible NOSC comes on. Tempo-wise, mantras are usually repeated in the same range as the chants mentioned before.

---

[205]Lee MS, Bae BH, Ryu H, Sohn JH, Kim SY, Chung HT. "Changes in alpha wave and state anxiety during ChunDoSunBup Qi-training in trainees with open eyes." *Am J Chin Med*. 1997;25(3-4):289-99.
[206]Janowiak JJ, Hackman R. "Meditation and college students' self-actualization and rated stress." *Psychol Rep*. 1994 Oct;75(2):1007 - 10.
[207]Seer P, Raeburn JM. "Meditation training and essential hypertension: a methodological study." *J Behav Med*. 1980 Mar;3(1):59-71.
[208]Stigsby B, Rodenberg JC, Moth HB. "Electroencephalographic findings during mantra meditation (transcendental meditation). A controlled, quantitative study of experienced meditators." Electroencephalogr Clin Neurophysiol. 1981 Apr;51(4):434-42.
[209] Bernardi, L. *et al*. "Effect of rosary prayer and yoga mantras on autonomic cardiovascular rhythms: comparative study." *BMJ* 2001;323;1446-1449.

Lastly, I don't feel that it's necessary to go into a separate discussion of prayer, given all of its commonalities with meditation and mantra recitation. Its manner of focus on one idea for an extended period of time, the way that many prayers are looped over and over again, the resulting internal rhythm that they develop as they are repeated, have obvious parallels to the discussions presented so far.

Chapter 7: My Experiment

In light of all of the evidence that I've presented, it seemed completely appropriate for me to run my own EEG experiment to try to directly verify that monaural beat brainwave stimulation is really happening. I wanted to add some hard data to the discussion.

My study was double-blinded, and took place at the Stanford Sleep Laboratory, located at 780 Welch Road, Stanford, CA. I obtained human subjects approval and a $2000 grant from the Undergraduate Research Program at Stanford. Dr. Clete Kushida was my main supervisor. Chia-Yu Cardell and Eileen Leary, the lab's head technicians, trained me on the EEG equipment. I had a subject population of 12 randomly selected Stanford undergraduates. I took a health history of each subject before they were included in the study to screen out anyone who might not react well to an NOSC, if, in fact, one was induced during a run of the experiment. I was looking for subjects who were not depressed, had not been depressed recently, had not experienced any major emotional or physical traumas 6 months prior to beginning the study, and who were not anxious. Each subject came into the lab on 3 separate days for 3 hours each day. The first day, I gave them each a tour of the lab before I began putting electrodes on their head. Before and after each run I asked them a series of questions about their state of mind, their degree of sleepiness, and their recent sleep habits. Those two questionnaires, along with the phone interview health history questions, are included in the Appendix. After I had them hooked up to the EEG machine, I gave them instructions regarding how the test was to be administered, which are also included in the Appendix. After the instructions, the subjects sat silently, with their eyes closed, for 10 minutes. During that time recorded

a baseline EEG for that day, to control for the varied states of arousal in which the subjects inevitably entered the lab each day. Following this control period, each day a different sound stimulus was played through headphones to the subjects. I used using three stimuli for the experiment; each was presented for 35 minutes, in different orders over the 3 days, to each subject. This was automated in order to keep the procedure double-blinded.

The stimuli were presented for 35 minutes in order to echo the protocol often associated with other meditation studies and real-life practice. Many of the other studies I've looked at regarding sound and the brain present stimuli for short periods, from 5 seconds to 4 minutes. These do a very poor job of approximating the kind of extended focus and practice conditions of normal meditation, which usually lasts for anywhere from 10 minutes to several days. Given the general time restrictions for the experiment, 35 minutes seemed like was going to be enough time to see if extended exposure to those stimuli could actually aid people in achieving the sorts of states of consciousness (alertness, relaxation, sleep) observed in many ritual contexts.

The stimuli all consisted of pulsed sine waves created from the combination of 2 different waves. The stimuli pulsed at 5Hz, 10Hz, and 14Hz (5Hz, for example, equals 5 pulses per second). The 5Hz pulse was created from 140 and 145Hz sine waves, mixed together into one monaural pulse. The 10Hz stimulus was created from 140 and 150Hz and the 14Hz stimulus from 140 and 154Hz. Each pulse falls into a different brainwave frequency range associated with a different state of consciousness. 5Hz is in the theta range (4-7Hz). Theta is associated with stage 1 and stage 2 sleep. If the frequency of a subject's brainwaves actually moved to 5Hz, in other words, their brainwaves entrained

to 5Hz, it have should induced a state of sleep in the subject. If their brainwaves entrained to the 10Hz stimuli, they should have entered an alpha state of consciousness. 10Hz is in the middle of the alpha range (8-13Hz). In eyes-closed conditions, it is often associated with the period of time before falling asleep. My subjects likely experienced alpha as a state of drowsiness, given the procedural instructions we gave them. 14Hz is near the bottom the beta range (14-30Hz). Beta range brainwaves are associated with being wide awake. If the subjects entrained to 14Hz, they would have had a more difficult time relaxing than with the alpha or theta range pulses and should have stayed awake throughout the experiment, or at least, have been awake longer than for either the alpha or theta conditions.

After the 35 minutes of stimulation, I had the subjects fill out another brief survey that had a few open-ended questions and the Stanford Sleepiness Scale. After the final run, I asked the subjects to fill a questionnaire designed to rate the characteristics of their state of consciousness immediately after the stimulation. This survey was the Phenomenology of Consciousness Inventory, developed by Pekala.[210] It is a widely accepted psychological survey to measure subjective states associated with NOSC experiences.

The data will be analyzed next fall to see how close the frequency of the subjects brainwaves moved to the frequency of the sound stimulus in each condition, adjusted to the baseline condition, and compared to the subjective reports from each day. As of right now, all that I've observed is that during the theta condition, close to 100% of the

[210]Maurer RL *et al*. "Phenomenological experience in response to monotonous drumming and hypnotizability." *Am J Clin Hypn*. 1997 Oct;40(2):130-4

subjects have fallen asleep. This might be an effect of how little sleep undergraduates get, and it may be an effect of the stimuli. The proper data analysis will hopefully tease out many interesting aspects of each stimulus condition.

Chapter 8: Conclusions

This argument was long and winding and I'm going to recapitulate it before I discuss its ramifications for several discourses. The first chapter offered several examples of NOSC experiences described in detail, and a discussion of vocabulary. Chapter 2 introduced the neural network model, and the connections between various brainwave phenomena, presented via EEG studies of attention, sleep, meditation, hypnosis, music, and a few medications, and their associated subjective experiences/states of consciousness. This information suggested connections between brainwaves and memory, emotion, and imagination, and states like concentration, relaxation, hypnogogia, and sleep. The chapter ended with a review of biofeedback, a thirty-year-old, extensively researched, applied use of brainwave information that has been used to diagnose and successfully treat a wide variety of ailments. Research on this modality suggested more connections between conscious states and brainwaves, revealing data on brainwave patterns associated with anxiety, depression, ADD, and other disorders like schizophrenia, epilepsy, and autism. This provided additional strong support for the previous connections between states of consciousness and brainwave patterns and also provided an additional example of the way that brainwaves can be systematically manipulated, which is an important idea given that I am trying to argue that with adequate attention music can systematically manipulate brainwaves.

After Chapter 3's history of the discourse on auditory entrainment, Chapter 4 presented the bulk of the scientific evidence that could be used to argue that brainwave entrainment can actually take place, and that it often leads to NOSCs. Chapter 5 and 6

complemented that discussion with an investigation of the various ritual technologies used to induce tempo-specific NOSCs in ritual contexts, many of which are extremely old, have remained in use until the modern day, and have extensive subjective data in the wider religious studies literature to back up their efficacy. Lastly, Chapter 7 presented the evidence that I collected in the Stanford Sleep Lab to try to support the various claims that I wanted to make in this thesis. This data seemed to support my hypothesis that monaural stimulation can drive brainwaves at a variety of frequencies, which is encouraging, but I can't conclude anything about those results until next year.

If you accept not only that auditory brainwave entrainment exists, which by association implies that photic and binaural entrainment are also real, but that the neural network and brainwave model I proposed is a useful framework for the analysis of conscious states, there are major ramifications for several discourses.

A. What this means for Religious Studies and Anthropology:

Ritual technologies are potent, and are doing more than satiating a desire to maintain tradition or to be preserved as symbols of faith. They are indispensable consciousness-manipulating techniques that help people in every religious tradition enter states of mind that are uniquely suited to encourage contemplation, transcendence, and ego-loss. These states provide a window to a view of the intimate connections, to the relationship of cause and effect, between you and the rest of the world.

The neural network model I proposed here can also provide a neuroscientific framework for the further analysis of EEG data that is relevant to the study of religion. The field of neuroscience is so broad, and there are so many different techniques

currently used to analyze the brain, isolating the EEG as a relevant source of information for this line of inquiry is not insignificant. A religious studies academic could waste a gigantic amount of time sifting through fMRI data, only to find that it tells him/her almost nothing about real-time conscious activity without combination with EEG analysis.

EEG analysis, in this context, could be used as an indispensable tool for the study of comparative religion, or for analyzing the experiences of two individuals of the same faith and ritual tradition. The possibilities for comparison between any individuals or groups with this analysis technique are new and immense. Since the advent of EEG, data collection has been on mile-long spools of paper that had to be hand-scored. Only in the last 10-15 years have personal computers become fast and inexpensive enough that this technology has been able to bloom and become more widely available. Now, data analysis that has never been possible before is widely feasible, and it can be accomplished many times faster than in the past. EEG use is only going to get easier and more convenient. This seems tremendously exciting given all that it could reveal about the workings and characteristics of any state of consciousness. My study used 13 electrodes. There are already electrode nets that have as many as 100 electrodes wired together. These numbers will keep climbing, and as they do, researchers will know more specifics about certain states because they will have more data and better tools of analysis. They will be able to hone in more precisely on what is indicated by the presence of various combinations of waves throughout the cortex. In terms of tracking states of consciousness and learning more about vivid religious experiences, this all seems very exciting.

In addition, as these brain-imaging technologies improve and scientists learn more about brain dynamics, neuroscience will only become a richer avenue to pursue when studying trance, meditative traditions and NOSCs.

B. What This Means for Neuroscience in General:

This argument will hopefully convince any practicing neuroscientist that the electro-magnetic level of brain activity is an extremely dynamic and interesting avenue of inquiry, and it needs to be acknowledged alongside cellular studies, especially given the state of the field at this time. Currently, millions of dollars are being spent, at least in the United States, on fMRI research, a scanning technology devoted entirely to tracking blood flow through the brain. It is oriented towards the cellular level of phenomena, rather than the electro-magnetic. Given what is known about the brain right now, at this moment in time, this is not necessarily the best avenue of exploration, and it is arguably a far less profitable avenue of research given how successful EEG and MEG research has been so far. fMRI may be a scientific fad currently plaguing neuroscience, in the sense that it is diverting funds from a useful technology (EEG) to an expensive camera whose pictures no one really understands. EEG is more than 10 times cheaper to operate, takes far less equipment, and shows a picture of the brain that is extremely interesting, especially when it is combined with careful subjective reports—which can be tracked in real-time. The framerate on an fMRI machine today is 2 seconds at best. EEG machines can take up to 1000 samples per second at best. EEG gets drastically closer to the actual speed at which the human brain is moving, turning subjective reports, which are

ubiquitous in religious studies and anthropology, into compelling data that can be compared with a real-time EEG brain-scan.

In addition, using photic, binaural, and monaural entrainment to manipulate subjects in order to observe their brainwave and cellular-level changes seems like a very exciting idea. More, with this technology, it is possible to systematically and quickly induce a deep NOSC state, and then bring the subject out of it in an equally brief amount of time. Compared to other forms of NOSC inductions, like spinning around, hyperventilation, starvation, or the use of medications, all of which induce NOSCs for hours if not days before the subject comes back to their baseline state of consciousness, the forms of brainwave stimulation featured in this paper seem like remarkably compelling options for studying NOSCs, and possibly religious experiences, in a lab setting.

Finally, the fact that meditative practices have a firm grounding in the oscillating neural network model of the brain should make them more attractive to study for neuroscientists in general. The type of information presented here could inspire much more neuroscientific research into both the subjective literature and lab experiments regarding trance, meditation and the nature of consciousness if only because of the links it makes between subjective reports and real-time brainwave information.

C. What This Means for Therapy in General:

In addition to the therapeutic benefits that can come from experiencing NOSCs, which can be induced via the repetitive stimulation that's been discussed, there are

simpler and extremely beneficial effects in the therapeutic realm that seem to come from this technology.

For instance, the consciousness shift from waking to sleeping is common, but extremely difficult for many people. Forty percent of Americans experience occasional insomnia and one in ten have it chronically.[211] It seems like photic stimulation, binaural and monaural beats are all excellent, non-medication-related options for anyone who wants to fall asleep, relax, or wake up and concentrate. Several family friends of mine are already using a monaural 4Hz pulse CD that I made them to relax before bed, and to fall asleep completely. Of the four of them, all of whom have had some success with the CD, mostly to help them relax, one of them, who will remain anonymous, has had a dramatic reaction.

She is in her late fifties, and has been having night sweats ever since a surgery on her heart several years ago that required hormone therapy as part of her recovery process. Every night, she would wake up between one and three in the morning, too hot to sleep. It would take her between two and three hours of watching TV or surfing the Internet to calm down enough to fall back to sleep, if she could get back to sleep at all. She told me that about 10 nights out of the month she was unable to fall asleep after one of these episodes, no matter what she did. She also told me that she'd tried changing her diet, various medications and sleeping pills, and none of it worked in a way that she thought was healthy for her.

I made her a seventy-minute CD with a 4Hz pulse on it. I told her to listen to that instead of watching TV or surfing the Internet to see if it helped. When I gave it to her, I

[211] Larson, Heather, Kemp, Gina, Segal, Robert. http://www.helpguide.org/aging/sleep_aids_medication_insomnia_treatment.htm 5/20/05.

figured seventy minutes was about how long it would take for her to fall asleep, if that happened at all. Within a week, she reported that she was falling asleep within twenty minutes, five out of the six nights since we'd spoken. She was thrilled. She also reported that one of those nights she turned the CD on in her kitchen, thinking that she would try to get drowsy and then go to bed, and she told me she woke up the next morning around 8:00 AM in her living room, having slept longer than she had in years. The next week, she had a trip to Washington DC that she almost skipped because she thought it would mess up the success she'd been having with her sleep. She took the CD on the trip, and slept soundly both nights.

After two months with the CD, she was falling asleep six out of seven nights in twenty minutes. This was an improvement of six full nights of sleep per month, plus the reduction in hours of wakefulness that she was experiencing during the night from two to three hours to twenty minutes. She had been on a diet as part of over-eaters anonymous during this period, and was working out more than normal. She reported that as she got more and more sleep, her workouts got longer, and she was able to lose more weight. She had more energy and it led to a variety of changes in her life.

She is also a unique individual. She is very audio-oriented. She loves music, and told me a story once that when she reads books she skips over the descriptions of things a lot of the time because she can't picture what's being described. She's also a mathematician. Sound clearly worked well for her. For more visual people, photic entrainment may be a better option. The two can also be combined.

Sonic therapy is already taken very seriously by a small contingent. Most people have not tried it. The sonic therapy literature is as lacking in proof of the efficacy of their

methods as the anthropology literature is in systematic proof of brainwave entrainment. As far as I can tell, this is an intensely attractive form of medical treatment that hopefully will be taken more seriously with more studies like mine. The possibilities of treatment with personal stereos is staggering. The fact that this delivery system is available so widely has probably paradoxically kept people from taking it more seriously as a therapeutic tool, at least in the sense of using it in place of medications or supplementing them. But a hundred years ago, if you wanted to hear music, you had to get a band together, or go find one, and have a musical experience. The fact that this experience is available today compactly, cheaply, and intensely accessibly has got to be taken advantage of.

In addition, the use of light stimuli to entrain brainwaves is equally if not even more compelling than auditory entrainment. In my experience with a light and sound device, light entrainment is bizarrely fast and effective. Given the research on brainwaves and biofeedback presented here that's revealing the varied benefits of stimulating these waves in certain ways, this sort of therapy may have a wildly successful future ahead of it.

The only reason that I believe these forms of treatment have not been more widely accepted, researched, and sought after is because of the vocabulary used to talk about them. Right now, flashing light devices and sonic therapy tapes and CDs are only sold on very New-Agey websites, by New-Agey people, talking in New-Agey-speak. This meta-physical jargon simply doesn't translate for most people, and I believe it has kept these products from being taken more seriously by a wider community, especially the scientific community, which has its own biases and fears about being too closely associated with

such folks. In this paper I tried to translate this jargon into the pseudo-priestly jargon of Science, which is equally impenetrable in a lot of ways, but given our culture, is much better trusted and more widely accepted than words about energy and God. I tried to keep this paper from using too much vocabulary that was unexplained, and I tried to keep it clear, so that my reader didn't have to be a theologian or a scientist to understand what I was saying.

C. What this means for me personally:

Beyond the work that I will likely do related to the therapeutic applications of these various ritual technologies, this whole investigation has simply changed the way that I think about the world. Even the connections that I've made on the level of folk-wisdom have been intensely enjoyable. How do you put a baby to sleep? You sit them on a washing machine, with its constant vibration and repetitive sound, you rock a baby, you pat a baby, you walk with a baby. Or you take a car ride and let them feel the even vibration of the road and the constant rhythm of the engine. How do you feel better? Have someone give you a massage with even rhythmic kneading, or tapping. Go on a jog, get in a rhythm and stay with it for a while. On the religious studies front, I see Jews davening and praying in rhythm, Buddhists reciting mantras as they prostrate 100,000 times, Christians praying to the rhythm of rosary beads kneaded in their hands, the use of torches in ritual dancing, dancing in general, the lights at rock concerts, speaker-huggers[212] at raves.

My life as a drummer has expanded and enveloped almost my entire world. The groove is everywhere now. When I think of music, I see a reflection of the most

[212] This is the word for the people who climb inside or hug the speakers at raves, enjoying the constant, body-vibrating bass beats.

fundamental interlocking processes in our bodies…the harmony we play echoes the harmonic relationships of every vital system- our heartbeat, our breathing, our brainwaves pulsing, our neuronal firing, our cells throbbing, our metabolic, enzymatic, and hormonal rhythms- and our behaviors- in our addictions and our habits.

In the past year "the groove" has taken on more meanings and more dimensions than I could possibly explain. And it has all completely changed the way I play. The notion of composite rhythm, and the obvious necessity implied by entrainment to not only keep a beat in time, but to actually keep the same sounds going, has distilled the drumset for me. The floating feeling I used to have during drum fills, when the groove would suddenly stop and I wouldn't know what happened, is becoming more and more infrequent. Now I know why the groove goes away when it does. It's because I stopped paying attention to it. My drum teacher refers to this as the beat within the beat. There's always a pulse in whatever you're playing, and there's always an engine rhythm. That rhythm is the entraining rhythm. The beat within the beat is my mantra. And you can feel it. When it's not there, you don't know what happened, you just know that things feel totally different and that you have come back to reality for a brief and unexpected moment. In my world, the groove is everything, and entrainment may suggest why.

And more, as a performer and as a player, to understand the meditative aspects of music is rich. The Buddhist notions of mindfulness that I've been studying for years are suddenly ringing wildly every time I sit down to practice. And as a performer, knowing where I can take people, can take their minds, if they listen hard enough, is also intensely exciting and meaningful. I know that I'm doing something good for everyone's brain in the room if I am playing a beat, in time, and with feeling.

But it goes farther: I know at least a little more now about the experiences that are out there waiting for me as a musician. I have a reason now to master my instrument. With mastery, with freedom from the technique, will certainly come experiences that will be as meaningful as any that I will have while I'm alive.

I'd like to end with a passage from The Chanting Book, written by Master Seung Sahn. He writes of the vibrating, beautifully complementary world of sound and attention that we've wandered through during these pages:

> Chanting meditation means keeping a not-moving mind and perceiving the sound of your own voice. Perceiving your voice means perceiving your true self or nature. Then you and the sound are never separate, which means that you and the whole universe are never separate. Thus, to perceive our true nature is to perceive universal substance. With regular chanting, our sense of being centered gets stronger and stronger. When we are strongly centered, we can control our feelings, and thus our condition and situation… However, when we do chanting meditation correctly, perceiving the sound of our own voice and the voices all around us, our minds become clear. In clear mind, there is no like or dislike, only the sound of the voice. Ultimately, we learn that chanting meditation is not for our personal pleasure, to give us good feeling, but to make our direction clear. Our direction is to become clear and enlightened, in order to save all beings from suffering… What's important is to perceive the sound and become one with it, without making "I" and "sound." At the moment of true perceiving, there is no thought, no separation, only perceiving sound. This is the crucial point. So during chanting time, perceive your own voice and the voice of others, just perceive this bell or drum sound, and cut off all thinking. Then your wisdom will grow, you will get enlightenment, and thus save all beings.[213]

[213] Morris, P. *One Sound: Traditional Buddhist Music From Tibet, China, Vietnam, Korea, Sri Lanka, and Japan booklet*. Ellipsis Arts…:Ellipsis Arts…Copyright 2000. Pg. 24.

Appendix

Phone Interview

I gave this interview over the telephone after I'd gotten a reply from a subject who had expressed interest in participating in the study, either by calling the flier number, by responding to one of my phone calls, or to one of my e-mails:

DAY & TIME: _____

PROFILE AND HEALTH HISTORY

NAME:
_____

AGE: _____ SEX: M F

1. How many hours of sleep did you get per night, on average, for the last 7 days?

2. How many nights in the last 7 days did you feel like you didn't get enough sleep? i.e. You were tired the next day, were daydreaming, felt sluggish?

3. How many nights of sleep have you missed in the last month?

4. How many hours of sleep did you get per night, on average, for the last two months?

5. Have you suffered through any period of mental or physical trauma in the last six months due to circumstances either in or beyond your control?
If yes, when and of what nature?

6. Do you have epilepsy? Y N

7. Have you ever had a seizure? Y N

8. Have you ever looked into a strobe or flashing light? Y N

9. Would you say you have been depressed for more than a few days at a time in the last month? Y N

10. Have you experienced any periods of intense anxiety in the last month? Y N

Script for rules to participate:

"I have three more questions for you and then we're done.
First, if you smoke cigarettes, would you be alright not smoking for at least 2 hours prior to coming into the lab?

Because it's a brainwave study, and cigarettes affect your brainwaves, we need to control for any outside substances you might be taking before you come in.
So, along those same lines, if you drink or take other recreational substances, would you agree to refrain from using them for at least 24 hours before coming into the lab?

And lastly, do you take any prescription drugs? Would you please list them for me?"

Doesn't qualify condition: "Thank you very much for your time. I'm sorry, but I can't use you in this study." (Explain why at this point)

Qualify condition: "Great. You qualify to participate in the study. Would you still like to participate? Great. I'm going to list several times that are available; please let me know which ones work the best for you."
OR
"If now is not convenient, I'll contact you by e-mail and work out a schedule. Thanks a lot."

Experiment Script

"Would you like to go to the bathroom before we start?

Thank you again for volunteering to help with this experiment. We're interested in learning about the effects of sound stimuli on brainwaves. In a second, we are going to begin today's experimental run. If at any time you feel uncomfortable or want to stop the experiment, that's totally fine. Just let
me know. I'll be here the whole time in case you need anything. The next hour will go as follows: I'll calibrate the equipment by asking you a few questions. Next, you'll sit for 10 minutes while I get some baseline readings. After that, you'll put on the headphones that are sitting next to you and I will play you a sound recording for 35 minutes. When that's finished, I'll ask you to answer a few more questions.

Do you have any questions before we start?

Go ahead and settle yourself into a comfortable position. If you want, take off your shoes, glasses, watch, anything constricting or distracting…. Now please put the headphones on that are sitting next to you- for now they're not going to play anything.

I'm going to calibrate the equipment now and make sure everything is working correctly. (At this point, I'll check to see that all the electrodes were hooked up properly and that all the equipment is calibrated correctly.)

Great. Now I'd like you to close your eyes and relax. I'm going to take more baseline readings and I'll come back in here after 10 minutes.

Do you have any questions?

Ok, great. Please sit back and relax and I'll get things started.
(For 10 minutes I'll record their baseline state of consciousness with their eyes closed.)

(At this point they take the Stanford Sleepiness Scale survey and answer the current health questions. If everything looks ok, we move on to the sound stimulus phase.)

Ok. If you want, you can make yourself comfortable again. The sound you are about to listen to is supposed to help you relax. I'd like you to listen to the sound and keep your eyes closed for the duration of the session. When it fades out this stage of the experiment will be over.

Do you have any questions?
(I'll run the 35 minute stimulus.)
Great. I'm going to ask you a few questions, and we'll be finished for today."

(I'll give the post-test survey questions here. After the third day I'm going to give them the PCI.)

Current Health Interview

Name: _____ For office use only:

Date: _____ Subject # _____

Time: _____

1. Please circle one number on the sleepiness scale rating:

The Stanford Sleepiness Scale (SSS)

Degree of Sleepiness	**Scale Rating**
Feeling active, vital, alert, or wide awake	1
Functioning at high levels, but not at peak; able to concentrate	2
Awake, but relaxed; responsive but not fully alert	3
Somewhat foggy, let down	4
Foggy; losing interest in remaining awake; slowed down	5
Sleepy, woozy, fighting sleep; prefer to lie down	6
No longer fighting sleep, sleep onset soon; having dream-like thoughts	7
Asleep	X

Please circle your response:

2. Did you get a good night's sleep last night? Y N

3. How many hours of sleep did you get per night, on average, during the last 7 days? _____hrs

4. How many nights in the last 7 days did you feel like you didn't get enough sleep? i.e. You were tired the next day, were daydreaming, felt sluggish… _____ nights

5. How many nights of sleep have you missed in the last month? _____ nights

6. How many hours of sleep did you get per night, on average, for the last two months? _____ hrs

7. Have you suffered through any period of mental or physical trauma in the last six months due to circumstances either in or beyond your control? Y N

If yes, when and of what nature?

8. Would you say you have been depressed for more than a few days at a time in the last month? Y N

9. Would you say you have been very anxious for more than a few days at a time in the last month? Y N

10. Are you right or left-handed? Right Left

Follow-Up Questions

Name: _____ For office use only:

Date: _____ Subject # _____

Time: _____

1. Please circle one number on the sleep scale rating:

The Stanford Sleepiness Scale (SSS)

Degree of Sleepiness	**Scale Rating**
Feeling active, vital, alert, or wide awake	1
Functioning at high levels, but not at peak; able to concentrate	2
Awake, but relaxed; responsive but not fully alert	3
Somewhat foggy, let down	4
Foggy; losing interest in remaining awake; slowed down	5
Sleepy, woozy, fighting sleep; prefer to lie down	6
No longer fighting sleep, sleep onset soon; having dream-like thoughts	7
Asleep	X

Please answer the following questions briefly:

2. Is there anything you would like to comment on about your experience today?

3. What were your expectations coming into this study?

CONSENT FORM

FOR QUESTIONS ABOUT THE STUDY, CONTACT:
Gabe Turow Email: gabet@stanford.edu Phone: 650-468-4084.

DESCRIPTION: You are invited to participate in a pilot research study on sound stimuli and brainwaves. You will be asked to listen to sound stimuli for 35 minutes while your brainwaves are monitored on an EEG machine. Before and after the experiment you will be asked several questions about your health and your experience of the experiment. All results from this test will remain confidential, and your name will not be associated with their publication.

RISKS AND BENEFITS: As with all experiences involving stimulation of the of mind, we cannot predict whether the experience will be positive, negative, or neutral. As such, the risks associated with this study are experiencing unpleasant visions, thoughts, emotions, and memories. The benefits which may reasonably be expected to result from this study are pleasant visions, thoughts, emotions, and memories as well as relaxation, release from stress, and increased peace of mind.

TIME INVOLVEMENT: Your participation in this experiment will take approximately 6 hours, divided over 3 days that will not necessarily be consecutive.

PAYMENTS: You will receive 60 dollars for participating in this study.

LEGALLY, YOU CAN BE PAID ONLY IF YOU ARE A US CITIZEN, A LEGAL RESIDENT ALIEN (I.E. POSSESS A "GREEN" CARD), OR HAVE A WORK ELIGIBLE VISA SPONSORED BY THE PAYING INSTITUTION.

SUBJECT'S RIGHTS: If you have read this form and have decided to participate in this project, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty. You have the right to refuse to answer particular questions. Your individual privacy will be maintained in all published and written data resulting from the study. If you have questions about your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact - anonymously, if you wish - the Administrative Panels Office, Stanford University, Stanford, CA (USA) 94305-5401 (or by phone (650) 723-2480 - you may call collect).

The extra copy of this consent form is for you to keep.

PRINTED NAME: _____

SIGNATURE: _____ DATE: _____

PROTOCOL APPROVAL DATE: 12/17/04
PROTOCOL EXPIRATION DATE: 5/27/05

PHENOMENOLOGY OF CONSCIOUSNESS INVENTORY (PCI)

Name_____ Date_____

INSTRUCTIONS

Please answer the following questions in reference to your experience of **today's** sound stimulus session.

I'd like you to use a **circle** to mark your answers on the **5-point** rating scale.

Each scale is a continuum between polarities.

Please circle **one number** on each 5-point scale:

1

I was forever distracted and unable to concentrate on anything.	1 2 3 4 5	I was able to concentrate well and was not distracted.

2

My thinking was clear and understandable.	1 2 3 4 5	My thinking was unclear and not easy to understand.

3

The thoughts and images I had were under my control; I decided what I thought or imagined.	1 2 3 4 5	Images and thoughts popped into my mind without my control.

4

I had an experience which I would label as very religious, spiritual or transcendental.	1 2 3 4 5	I did not have an experience which I would label as religious, spiritual or transcendental.

5

I became aware of very intense sexual feelings.	1 2 3 4 5	I experienced no sexual feelings.

6

I was silently talking to myself a great deal.	1 2 3 4 5	I did not engaged in any silent talking to myself.

7

I felt very, very sad.	1 2 3 4 5	I felt no feelings of sadness whatsoever.

8

My attention was completely directed towards my own internal subjective experience.	1 2 3 4 5	My attention was completely directed towards the world around me.

9

I felt ecstatic and joyful. — I felt no feelings of being ecstatic or joyful.

1 2 3 4 5

10

I cannot remember what I experienced. — I can remember just about everything that I experienced.

1 2 3 4 5

11

My body ended at the boundary between my skin and the world. — I felt my body greatly expanded beyond the boundaries of my skin.

1 2 3 4 5

12

I experienced a great deal of visual imagery. — I experienced no visual imagery at all.

1 2 3 4 5

13

I was not aware of being aware of myself at all; I had no self-awareness. — I was very aware of being aware of myself; my self-awareness was intense.

1 2 3 4 5

14

I felt no emotions of rage whatsoever. — I felt enraged.

1 2 3 4 5

15

My perception of the flow of time changed drastically. — I noticed no changes in my perception of the flow of time.

1 2 3 4 5

16

I felt very frightened. — I felt no emotions of frightened.

1 2 3 4 5

17

My perception of the world changed drastically. — I noticed no changes in my perception of the world.

1 2 3 4 5

18

My visual imagery was so vivid and three-dimensional, it all seemed real. — My visual imagery was so vague and diffuse, it was hard to get an image of anything.

1 2 3 4 5

19

The muscles of my body felt very tense and tight. — The muscles in my body felt very loose and relaxed.

1 2 3 4 5

20

I experienced no feelings of love. — I experienced very strong feelings of love.

1 2 3 4 5

21

My state of consciousness was not any different or unusual from what it ordinarily is. — I felt an extremely different and unusual state of consciousness.

1 2 3 4 5

22

I can recall nothing that that happened to me. — I can recall everything that happened to me.

1 2 3 4 5

23

I had an experience of awe and reverence towards the world. — I had no experience of awe and reverence towards the world.

1 2 3 4 5

24

Conceptually, my thinking was clear and distinct. — Conceptually, my thinking was confused and muddled.

1 2 3 4 5

25

I had complete control over what I was paying attention to. — I had no control over what I was paying attention to.

1 2 3 4 5

26

My bodily feelings seemed to expand into the world around — My bodily feelings were confined to the area within my skin.

1 2 3 4 5

27

I was continually conscious and well aware of myself. — I lost consciousness of myself.

1 2 3 4 5

28

My attention was totally directed towards the environment around me. — My attention was totally directed towards my own internal subjective experience.

1 2 3 4 5

29

The world around me became extremely different in color and form. — I noticed no changes in color or form in the world around me.

1 2 3 4 5

30

Time seemed to greatly speed up or slow down. — Time was experienced with no changes in its rate of passage.

1 2 3 4 5

31

I felt no feelings of unhappiness or dejection. — I felt unhappy and dejected.

1 2 3 4 5

32

I experienced no profound insights besides my usual cognitive understanding of things. — I experienced very profound and enlightening insights of certain ideas or issues.

1 2 3 4 5

33

I felt very angry and upset. — I felt no feelings of being angry or upset.

1 2 3 4 5

34

I was not distracted, but was able to be completely absorbed in what I was experiencing. — I was continually distracted by extraneous impressions or events.

1 2 3 4 5

35

I was not aware of any sexual feelings. — I experienced very strong sexual feelings.

1 2 3 4 5

36

My thought processes were nonrational and very hard to comprehend. — My though processes were rational and easy to comprehend.

1 2 3 4 5

37

I felt no feelings of tension or tightness at all. — I felt tense and tight.

1 2 3 4 5

38

My memory of the events I experienced is extremely clear and vivid. — My memory of the events I experienced is extremely blurred and hazy.

1 2 3 4 5

39

I noticed no changes in the size, shape, or perspective of the objects in the world around me. — Objects in the world around me changed in size, shape, or perspective.

1 2 3 4 5

40

My state of awareness was very different from what I usually experience. — My state of awareness was no different than usual.

1 2 3 4 5

41

I relinquished control and became receptive and passive to what I was experiencing. — I was willfully controlling what I was experiencing.

1 2 3 4 5

42

I felt no feelings of being scared or afraid. — I felt very scared and afraid.

1 2 3 4 5

43

I felt no sense of timelessness; time flowed as I usually experience it. — Time stood still; there was no movement of time at all.

1 2 3 4 5

44

I experienced no or very few images. — My experience was made up almost completely of images.

1 2 3 4 5

45

I did not engage in any silent talking to myself. — I was silently talking to myself a great deal.

1 2 3 4 5

46

I experienced no feelings of ecstasy or extreme happiness beyond my usual feelings.

I felt feelings of ecstasy and extreme happiness.

1 2 3 4 5

47

I experienced no sense of sacredness or deep meaning in existence beyond my usual feelings.

Existence became deeply sacred or meaningful.

1 2 3 4 5

48

My imagery was very vague and dim.

My imagery was as clear and vivid as objects in the real world.

1 2 3 4 5

49

I felt intense feelings of loving-kindness.

I felt no feelings of loving-kindness.

1 2 3 4 5

50

I maintained a very strong sense of self-awareness the whole time.

I did not maintain a very strong sense of self-awareness at all.

1 2 3 4 5

51

I continually maintained a very strong sense of separation between myself and the environment.

I experienced intense unity with the world; the boundaries between me and the environment dissolve away.

1 2 3 4 5

52

My attention was completely inner-directed.

My attention was completely completely outer-directed.

1 2 3 4 5

53

My state of awareness was not unusual or different from what it ordinarily is.

I felt an extraordinarily unusual and nonordinary state of awareness.

1 2 3 4 5

54

My attention was only focused on one subjective event at a time.

My attention was focused on many subjective events simultaneously.

1 2 3 4 5

55

Too many thoughts, feelings, sensations, etc. kept rushing through my mind.

Not a single thought, feeling, sensation, etc. went through my mind.

1 2 3 4 5

56

I felt my consciousness to be very much within my body.

I felt my consciousness to be "out of" and disconnected from my body.

1 2 3 4 5

57

I felt a spatial expansion of my awareness; I felt like a sphere of consciousness and was simultaneously aware of everything within the sphere of consciousness.

I felt no spatial expansion of awareness; I did not feel like a sphere of consciousness and was not aware of everything simultaneously.

1 2 3 4 5

58

I felt I was willfully and actively controlling what I was attending to.

I stopped actively controlling what I was attending to and and became passive and receptive to my experience.

1 2 3 4 5

59

I was not continually scanning and observing my attentional field for different occurring events and impressions.

I was continually scanning and observing my attentional field for occurring events and impressions.

1 2 3 4 5

60

I became extremely distracted and was not able to become absorbed in what I was experiencing.

I was able to become so absorbed in what I was experiencing, I gave no notice to distracting events.

1 2 3 4 5

61

My attention was totally directed towards the environment around me.

My attention was totally directed towards my own internal subjective experience.

1 2 3 4 5

62

My mind became one pointed; I was able to focus on one thing to the exclusion of all others.

My mind was not one-pointed; many different impressions or thoughts intruded into my awareness.

1 2 3 4 5

63

I was not equally attentive to every thought, feeling, sensation, etc. in my stream of consciousness; I focused on some impressions to the exclusion of others.

I was equally attentive to every thought, feeling, sensation, etc. in my stream of consciousness.

1 2 3 4 5

64

I felt my attention was very flexible; I could easily focus my attention on any thought, or sensation that came to my attention.

My attention was not very flexible; I felt many thoughts, feelings, and sensations that I could not get out of my mind.

1 2 3 4 5

65

I merged with the objects of my attention and lost my objectivity and detachment.

I thought I was attending to the objects in my mind in a very objective and detached manner.

1 2 3 4 5

66

My mind was in a state of "no thought", I was not aware of a single thought, sensation, etc.

My mind was continually occupied; I was always aware of thoughts, feelings, sensations, etc.

1 2 3 4 5

67

My attentional focus was not spatially expanded; my consciousness did not feel like a sphere of awareness illuminating everything within it.

My attentional focus was spatially expanded; my consciousness felt like a sphere of awareness illuminating everything within it.

1 2 3 4 5

68

I did not experience my consciousness to be outside of or separated from my physical body.

I actually experienced my consciousness to be outside of and separated from my physical body

1 2 3 4 5

69

I became deeply absorbed in what I was attending to; I lost track of the world around me.

I did not become deeply absorbed in what I was attending to; I was extremely aware of the world around me.

1 2 3 4 5

70

I was able to "let go" and experience whatever came to my attention.

I was actively involved in controlling what I was attending to.

1 2 3 4 5

71

My attention was completely outer-directed.

My attention was completely inner-directed.

1 2 3 4 5

72

I felt it very difficult to move and focus my attention; my mind kept returning to certain impressions.

I was easily able to move, control and focus my attention on whatever impressions that came into mind.

1 2 3 4 5

73

I was simultaneously aware of everything at once; I could perceive many subjective events simultaneously.

I was not simultaneously aware of everything at once; I could not perceive many subjective events at once.

1 2 3 4 5

74

I felt very distant and detached from my thoughts, feelings, and sensations.

I felt absorbed in my thoughts, feelings, and sensations.

1 2 3 4 5

75

I was able to easily and completely focus my mind on a single impression or event for as long as I wanted.

I found it impossible to focus my mind on a single impression or event for any length of time at all.

1 2 3 4 5

76

I was not able to experience each and every sensation, feeling, or thought equally; I focused on some of them more than others.

I was able to experience every sensation, feeling, or thought equally.

1 2 3 4 5

77

I was constantly aware of and scanning my internal and/or external environment for any changes in that environment.

I did not scan or try to be constantly aware of my environment for any changes in that environment.

1 2 3 4 5

78

I felt my awareness completely separated and distant from my body.

I felt my awareness to be focused or centered within my body.

1 2 3 4 5

79

My consciousness felt spatially expanded beyond my body so that I felt my awareness to be simultaneously everywhere.

My consciousness did not feel spatially expanded beyond my body; I did not feel my awareness to be simultaneously everywhere.

1 2 3 4 5

80

My attentional field was completely empty of any sensations, feelings, or thoughts at all.

My attentional field felt "crowded" with many sensations, feelings, thoughts, etc.

1 2 3 4 5

81

I was actively involved in controlling what I was attending to.

I was able to "let go" and receptively experience whatever came to my attention.

1 2 3 4 5

82

I was not able to become in what I was experiencing; I was acutely aware of other things around me.

I became so deeply absorbed in what I was experiencing that I became oblivious (neglectful) to everything else around me.

1 2 3 4 5

83

My attentional focus was very flexible; I had excellent control over what I wanted to attend to.

My attentional focus was rather rigid; I could not easily control what I wanted to attend to.

1 2 3 4 5

84

I was aware of many sensations, thoughts, feelings, etc. simultaneously

I was aware of only one sensation, thought, feeling, etc. at a time.

1 2 3 4 5

85

I felt detached or distant from my thoughts, feelings, and sensations.

I felt immersed or lost in my thoughts, feelings, and sensations.

1 2 3 4 5

86

I was equally aware of all the different impressions and events that went through my mind; I did not dwell on some more than others.

1 2 3 4 5

I was not equally aware of all the different impressions and events that went through my mind; I dwelled on some more than others.

87

My attention was not focused on a single subject or event; many other events or impressions intruded into my attention.

1 2 3 4 5

My attention was focused on a single impression to the exclusion of all other events.

88

I was extremely vigilant and continually observant of everything in my attentional field.

1 2 3 4 5

I was not vigilant or continually observant of everything in my attentional field.

89

My attention was completely directed towards my own internal subjective experience.

1 2 3 4 5

My attention was completely directed toward the world around me.