Music, Science, and the Rhythmic Brain

Cultural and Clinical Implications

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PART I. EFFECTS OF REPETITIVE RHYTHMIC MUSIC ON EEG AND SUBJECTIVE EXPERIENCE

In 1990, in her interest to explore the posited correlation between drumming tempi and brainwave responses, Melinda Maxfield arranged a lab-based replication of a shamanic drumming ceremony, monitoring subjects' electroencephalographic (EEG) responses while documenting their subjective experiences. Similarly, in 2005, Emil Jovanov completed an exploratory study on experienced yogic meditators, measuring heart rate variability and respiration responses to rhythmic chanting. Both studies, though focused on considerably different traditions, explore the ritual use of rhythmic auditory stimulation as a means to stabilize basic physiological rhythms (breathing, heartbeat, brainwaves) and facilitate altered states of consciousness.

Many oral traditions acknowledge that percussion in general, and rhythmic drumming in particular, facilitates communication with the spiritual world (Crawley, 1912; Rouget, 1985; Eliade, 1964; Needham, 1979; Hart, 1990; Harner, 1990). Shamanic ritual behavior fits this model: In the literature, shamans are most often described as healers, "technicians of the sacred," "masters of ecstasy," who use ritual drumming to deliberately enter into altered states of consciousness to discover information relevant to their patient's ailment and its treatment (Eliade, 1964; Walsh, 1989, 1990; Achterberg, 1985; Drury, 1982, 1989). In shamanic traditions, the drum is often described as a bridge between normal reality and the spirit world. Mircea Eliade, in his seminal work on shamanism, writes: "the shamanic drum is distinguished from all other instruments of the 'magic of noise' precisely by the fact that it makes possible an ecstatic experience" (Eliade, 1964. p. 174). Similarly, Michael Harner, founder of the Foundation for Shamanic Studies, notes: " . . . the repetitive sound of the drum is usually fundamental to undertaking the shamanic task . . . " (Harner, 1990, p. 51).

Despite the relative consensus among ethnomusicologists that drumming is an important catalyst for the shaman's transition into trance (Crawley, 1912; Eliade, 1964; Prince, 1968a, 1968b; Needham, 1979; Rouget, 1985; Hart, 1990; Harner, 1990), the exact relationship between drumming and altered

states is not well understood. There is, however, a variety of speculation on the specific role the drum plays in this process. These theories include:

1. Rhythmic drumming acts as a focus for concentration and is used in combination with sensory deprivation, fasting, fatigue, mental imagery, etc., to achieve an altered state of consciousness.
2. Rhythmic drumming is simply part of the "set and setting" dictated by the beliefs and ritualized ceremonies of the culture, and the altered state of consciousness is a product of pathology, trickery, and/or hallucinations stemming from an overactive imagination and hyper-suggestibility.
3. The rhythm of the drumming facilitates an altered state of consciousness.
4. The monotony of the drumming facilitates an altered state of consciousness.
5. The acoustic stimulation of rhythmic drumming acts as an auditory driving mechanism, affecting the electrical activity of the brain by bringing it into resonance (at a particular frequency or set of frequencies) with the external stimuli.

Harner emphasizes this latter theory in his arguments regarding the consistency in shamanic ritual drumming worldwide: It often takes the form of a steady beat, played at 3 to 4 and 1/2 pulses per second, for several hours (Harner, 1990). Neher's (1961) work on auditory driving and dissociation also emphasizes these tempi. Wolfgang Jilek, Emeritus Professor of Psychiatry, University of British Columbia, reports similar findings in his research on the ritual dance drumming of the Salish Indians (Jilek 1974). In this study, Jilek observed a predominance in drumming frequencies at 4 to 7 beats per second, a range that correlates with the theta wave frequency band (4–7Hz) of the human EEG. He hypothesized that stimulation in this frequency range would be the most effective aid to entering an altered state of consciousness, given the correlations between increased theta wave activity and hypnogogic imagery, states of ecstasy, creativity, and sudden illuminations (Achterberg, 1985; Green & Green, 1977).

Brainwaves and Subjective States

As briefly described in Chapter 1, brain electrical activity in various frequency bands is correlated with particular states of consciousness.

- Beta frequency activity (13–30Hz) is associated with active attention and focus on the exterior world, such as normal, everyday activities. Beta is also present during states of tension, anxiety, fear, and alarm (Green & Green, 1977; Spehlmann, 1981; Dyro, 1989).
- Alpha frequency activity (8–13Hz) is most often associated with states of relaxation. Alpha generally appears in the occipital region of the

brain (the visual cortex) when the eyes are closed. In this state, subjects are alert but unfocused, or focused on the interior world (Guyton & Hall, 2006).

- Theta frequency activity (4–8Hz) is usually associated with drowsy, near unconscious states, such as the threshold period just before waking or sleeping. The same activity has often been connected to states of reverie and hypnogogic or dream-like imagery. For most people, it is difficult to maintain consciousness without any outside stimulation during periods of increased theta activity (Tart, 1972; Wallace & Benson, 1972; Banquet, 1973). Research has confirmed that such practices as yoga and meditation produce changes in the electrical activity of the brain that can lead to a baseline increase in alpha and/or theta rhythms (Benson, 1975, p. 82; Murphy & Donovan, 1988). Interestingly, enhanced baseline theta and the maintenance of theta waves during meditation is found to be characteristic of long-term meditators who are able to maintain the theta state while keeping their self-awareness intact (Green & Green, 1986).
- Delta frequency activity (.05–4Hz) is associated with deep sleep or unconsciousness (Guyton & Hall, 2006).

Research

Maxfield's study relied on the biofeedback technology of MindCenter Corporation, formerly located in Palo Alto, CA. This multi-user system was a prototype 16-channel electroencephalographic biofeedback instrument (Grass) running under computer. The channel filters were tuned to broadband theta, alpha, and beta frequencies. The frequencies of the filters band pass zones were: theta, 4–6.7Hz; alpha, 7.7–12.6Hz; beta, 15–24Hz. The multi-user system was composed of four modules, each designed to block external sound and light. There was no specific temperature control. The participants were able to lie down inside the module in the traditional drum-journey[1] posture. Each module contained a sound system, consisting of a generic tuner and audio cassette player.

From these modules, four cortical sites were monitored for theta, alpha, and beta brainwave activity. Brainwaves were recorded from each participant on the following cortical sites: left parieto-central, right parieto-central, left parietotemporal, right parieto-temporal. Ground electrodes were placed in the center of the forehead, with reference electrodes for the differential amplifiers on both ears, in linked pairs.

Participants

Twelve subjects, 8 women and 4 men, were selected to participate in the study. The minimum age was 19; the maximum age was 68; the mean age was 39. Eight participants had completed 4 or more years of college, 2 had

Table 2.1 Tape Sequence Schedule

	1:00-4:00 Group A	4:30-7:30 Group B	7:30-10:00 Group C
Monday	I Ching	Free	Shamanic
Wednesday	Free	Shamanic	I Ching
Friday	Shamanic	I Ching	Free

completed 2 or more years of college, and 2 had completed, or were in the process of completing, 1 year of college. One of the main criterions for subject selection was limited experience with rhythmic drumming patterns and a lack of general knowledge regarding shamanic rituals. Additionally, no one with a history of psychosis, epilepsy, and/or other neurophysiological disorders was accepted to participate.

Psychological Testing Instruments

Four weeks prior to the first session, each participant completed a battery of mood scale tests (Dean J. Clyde Mood Scale [Clyde], Multiple Affect Adjective Check List [MAACL], Profile of Mood States [POMS]). These scales were mailed to participants in their initial information packet. The mood scale tests were administered again before and after each session. These results are not included here, but subjects' subjective reports are summarized below.

The 12 participants were divided into 3 groups of 4. Each group was tested in 3 sessions, on 3 separate days, for a total of 36 individual sessions. (The actual total of individual sessions was 35, as 1 participant canceled a session due to a work-related crisis.) Group A was in the laboratory from 1 to 4 p.m., Group B from 4:30 to 7:30 p.m., and Group C from 7:30 to 10:30 p.m. on Monday, Wednesday, and Friday during the testing week. Each group was exposed to three drumming tapes, one tape per day. Participants were monitored for EEG responses to each of the three tapes; the tapes were counter-balanced for each group during each session to control for order effects. In lieu of live drumming in the lab, four drummers were hired to record the experiment tapes in a local commercial sound studio. Each 20-minute tape featured one kind of drumming:

1. *Shamanic Drumming:* the type of "core" shamanic drumming journey described and popularized by Harner (1990), with sustained, monotonous beats in unison, ranging from approximately 4 to 4.5 beats per second (Hz), or 240–270 beats per minute (BPM).

2. *I Ching Drumming:* a rhythmic, syncopated drumming pattern, ranging from approximately 3 to 4Hz (180–240 BPM), inspired by (I Ching, 1950).
3. *Free Drumming:* incorporates no sustained rhythmic pattern.

Session Details

1. Upon their arrival at the laboratory, participants were fitted with electrodes.
2. The participants were escorted to the modules to which they had been assigned for the three sessions. Mood scale tests (MAACL, Clyde, and POMS) were administered via the computer contained in the module.
3. Upon completion of the mood tests, the participants were placed in a prone position on the module floor. Foam pads and pillows were provided for comfort. A technician connected the scalp electrode wires to the appropriate terminals. The module was then closed. Communication with the participants was accomplished through the module intercom system.
4. Participants were instructed by the technician to relax with eyes closed and to restrict body movements.
5. Baseline theta, alpha, and beta were taken, including and in the following order:
   - 4 minutes of baseline with eyes open;
   - 8 minutes of baseline with eyes closed;
   - 8 minutes of baseline with white noise (eyes closed).
6. A drumming tape was then played through the modules sound system for 20 minutes.
7. When the drumming tape ended, more baselines were taken, including: 8 minutes of white noise, 8 minutes eyes closed, and 4 minutes eyes open baselines.
8. The modules were opened. The technicians detached the electrode wires from the module connection so that the participants could sit in a chair to work the computer keyboard. Mood scales were again administered via the computer in the module.
9. Participants left the modules and were taken to a room where they were asked to give a brief written account of their subjective experience. Most were able to accomplish this task within 15 to 20 minutes. Art supplies were available for those who wished to capture their memories through drawing and color.
10. Participants were then given an interview (10 to 15 minutes) by the author in which they gave an oral summary of their experience. This interview was tape-recorded. These subjective experiences were then categorized according to recurring themes and consensual topics. Those who had

completed their written account and were waiting for an interview, used the time to allow the technicians to remove the scalp electrodes.

None of the participants were given information on imaging and/or the shamanic journey, and all had previously given assurance that they were naive to the details and the experience of shamanic journeying in the context of rhythmic drumming. After data collection was completed, movement artifacts were eliminated from the EEG record and corresponding digital printouts.

Results

Data were derived from wave amplitudes integrated during 15-second epochs to represent total EEG band power in theta, alpha, and beta from each site. Baseline scores were printed out every 15 seconds during the three-part baseline procedures. Scores during the drumming session were printed out every 2 minutes. In order to condense and interpret the sizeable amount of data obtained from these procedures, epochs were selected for analysis at 2, 9, 13, 15, and 20 minutes. These times were selected because:

- Sampling at 2 minutes would represent the state of subjects' brainwaves after initial settling in;
- Sampling at 9, 13, 15 minutes would record subjects optimum physiological response to drumming;[2]
- ampling at 20 minutes was used to determine final changes in frequency band power relative to baselines, and relative to previous epochs.

Absolute means on each time epoch for theta, alpha, and beta brainwave patterns, recorded at each of the four cortical sites, yielded a total of 72 per person per session, or a total of 2,592 absolute means. Mean difference scores (MDS) were obtained by subtracting each individual's absolute mean scores (obtained during the beginning white noise baseline) from every score for the five time epochs, the four cortical sites, and the three brainwave patterns, yielding a total of 2,160 MDS.

Example: Subject 1A (left temporal activity)
Theta absolute mean score baseline = +159
Theta absolute mean score for minute 2 during Shamanic Drumming = -135
Mean difference score = -24

This technique corrects somewhat for individual differences in EEG band power. Baselines were derived from the beginning white noise segments. As was normal protocol in this particular lab, the white noise incorporated random beeps that the participant was asked to count in order to reveal a picture of normal brain activity in a baseline alert state.

Group Means Differences (MDS) for Total Theta, Alpha, and Beta for Three Drumming Patterns

Group mean differences from baseline scores were derived for total theta, alpha,and beta (averaged for each of the four cortical sites), for minutes 2, 9, 13, 15, and 20 for each of the three drumming patterns. Two sets of graphs are presented: In the first set (Figure 2.1, Figure 2.2, and Figure 2.3), group means scores for total theta, alpha, and beta are shown. A separate graph is provided for each drumming pattern. In the second set

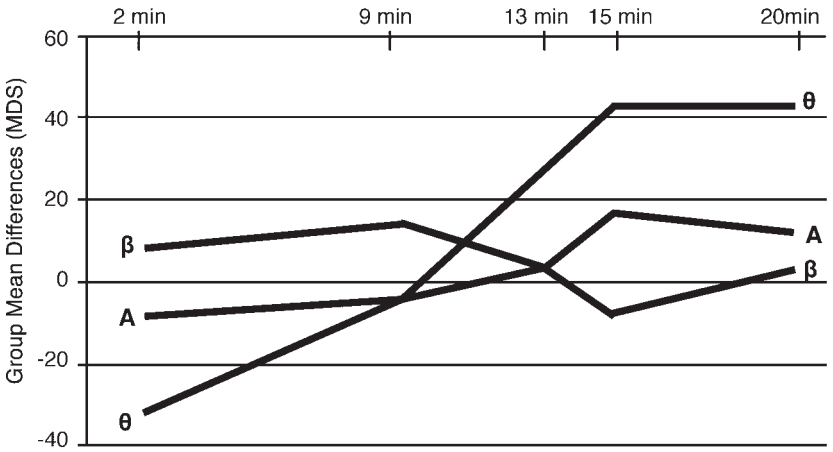

Figure 2.1 Group mean differences (MDS) for total theta, alpha, and beta for shamanic drumming.

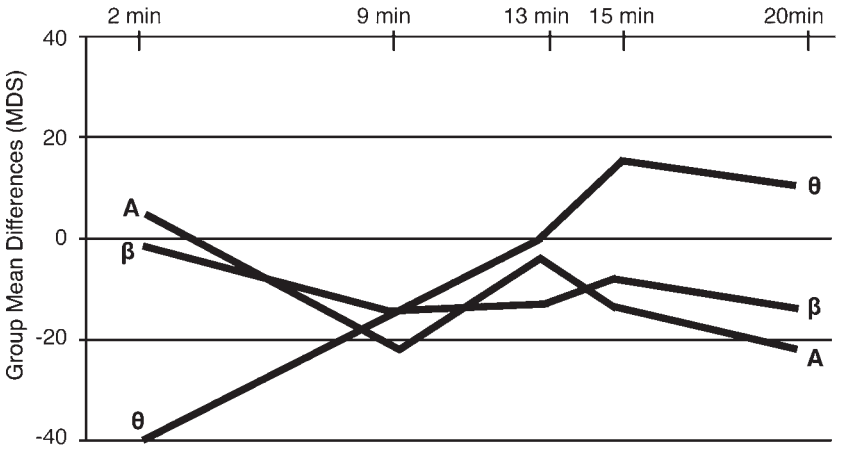

Figure 2.2 Group mean differences (MDS) for total theta, alpha, and beta for I Ching drumming.

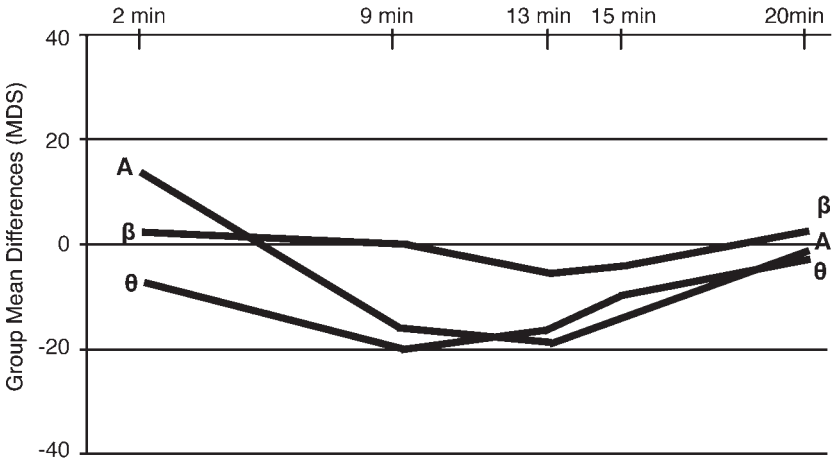

Figure 2.3 Group mean differences (MDS) for total theta, alpha, and beta for free drumming.

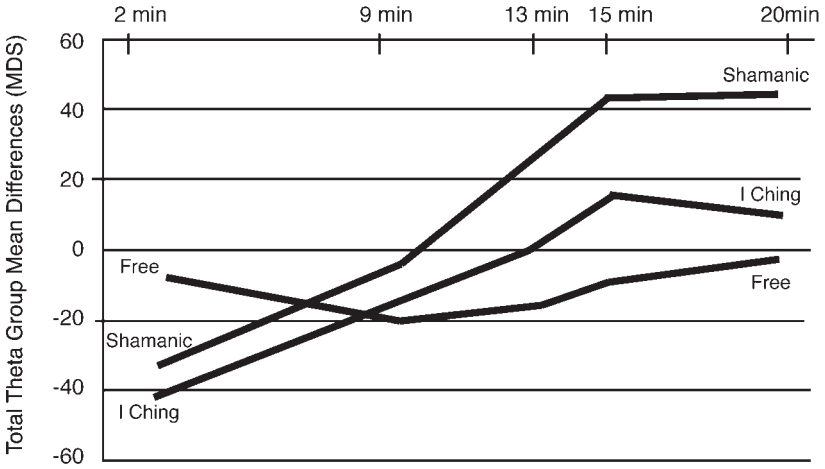

Figure 2.4 Total theta group mean differences (MDS) for the three drumming patterns.

(Figure 2.4, Figure 2.5, and Figure 2.6), a separate graph is provided for each brainwave frequency (theta, alpha, and beta).

The greatest response is seen during the Shamanic Drumming, which shows increased theta band power (Figure 2.1). The greatest response was measured from the right temporal lead, with a rapid rise to minute 15. The greatest gain in alpha is seen during Shamanic Drumming in the left

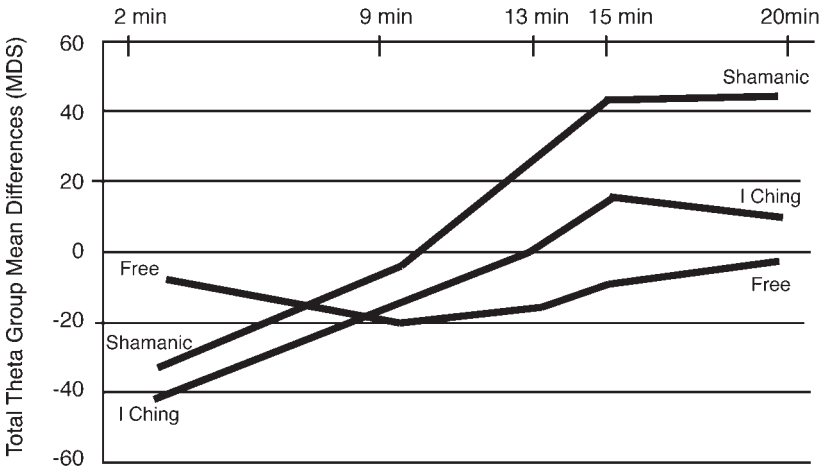

Figure 2.5 Total beta group mean differences (MDS) for the three drumming patterns.

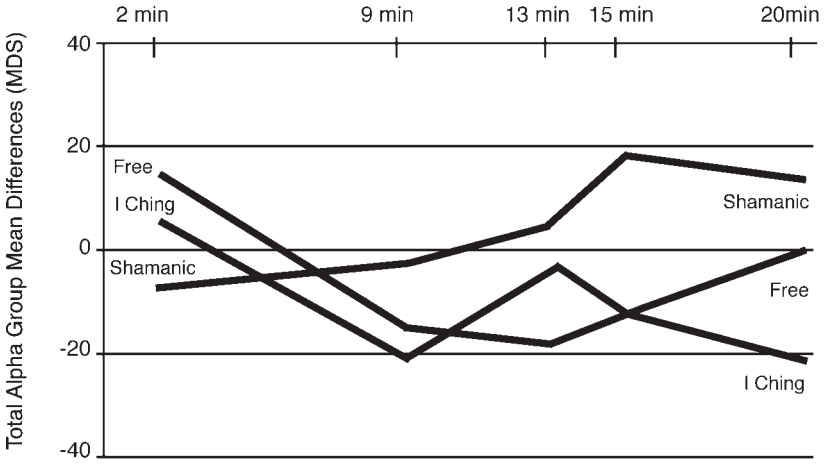

Figure 2.6 Total alpha group mean differences (MDS) for the three drumming patterns.

hemisphere, peaking at minute 15. A lesser increase in theta is found during the I Ching Drumming (Figure 2.2), peaking at minute 15; similarly, the greatest response was measured in the right temporal region. Brainwave activity for all three frequency bands appeared to remain constant or decline during Free Drumming (Figure 2.3). There was no significant gain in beta band power from any drumming pattern.

It is interesting to note that all 12 participants had visual and/or somatic imagery during stimulation. For 8 of these 12, the images were dreamlike, but vivid. The following short examples typify their accounts:

Subject A:

"Immediately, I saw a heart pumping to the beat of the drums. There were two drum beats to every heartbeat. . . . I saw an African dance, at night, with big drums and dancers in costumes. I viewed this from a distance." [Maxfield notes:] The subject reported that he was focused on the beat of the drums; the dancing was foggy and in the background. "The auditory beat was the main thing. . . . I was suddenly shot through a tunnel of darkness. I felt the movement up, like being in a channel. I had no clue how I got in it. All of a sudden, I was there. I ended up free in the outer universe. It was dark, but I had a real sense of freedom. It was great. I felt free, excited and relaxed—exhilarated, as if I had let go of something. My body felt a sense of uplifted exhilaration and freedom."

Subject B:

"The drumming emerged as geometric shapes—triangles, squares, and circles. There was lots of color, plus black—very vivid color. The patterns of the sounds went around in vivid colors."

Subject C:

"In the beginning, there was the sense of an Eskimo in a double-headed canoe. . . . Right after the Eskimos, in the beginning, I saw an abstract symbol that became a seal that beckoned me. I joined it and swam through a sea of blue calm. . . . I became a swimming projectile, moving very rapidly. . . . It was a very fast, forward-moving motion. Eventually, I approached a door, which became a series of doors, into the perspective. I went down through a tunnel. My body moved and bent with the tunnel and popped up in another part of the earth. . . . I had many, many, very vivid images. I was right there. . . . Indians, smoke, firelight, mountain lions, prairie-kinds of animals. . . . All of it was 'night-time stuff.' There was no 'daytime stuff' or people. . . . At one point, I saw the opening of a kaleidoscope, round, changing shape and color."

The first 12 categories listed below are the common themes as synthesized from the 12 participants' verbal and written reports of their experiences in one or more sessions during the drumming.

These include:

- Loss of Time Sense

Seven of the 12 participants stated that they had lost the time continuum, thus having no clear sense of the length of the drumming session.

- Movement Sensations
  Ten of the 12 participants experienced one or more Movement Sensation.
  This category includes the experience of feeling:
  —the body or parts of the body pulsating or expanding;
  —pressure on the body or parts of the body, especially the head, throat, and chest;
  —energy moving in waves through the body; and
  —sensations of flying, spiraling, dancing, running, etc.

- Heightened Arousal
  Nine of the 12 participants mentioned specifically that they became energized during and/or immediately after the drumming session.

- Temperature Fluctuations (Cold/Hot)
  Six of the 12 participants experienced sudden changes in temperature (e.g., chills, being flooded with warmth, sweating.).

- Relaxed, Sharp/Clear
  Five of the 12 participants noticed that they felt particularly relaxed, sharp, and clear. This was usually in lieu of more explicit emotional content.

- Discomfort
  Five of the 12 participants mentioned specifically that they were in varying states of emotional or physical discomfort.

- Journey
  Five of the 12 participants' descriptions of their experiences included classic shamanic journey imagery, such as going into a hole or a cave, being shot through a tube or a tunnel, spiraling up or down, being initiated, climbing an inverted tree, and/or the appearance of power animals and helping allies.

- Images
  —Vivid Imagery: All 12 participants had some imagery. Eight of the 12 commented on experiencing vivid visual or sensate (somatic) images.
  —Natives: Nine of the 12 participants saw or sensed African, Tahi-tian, Eskimo, or Native American natives. These natives were usually participating in rituals and/or ceremonies involving dancing, singing or chanting, hunting, or drumming.

—Animals/Landscapes: Seven of the 12 participants reported a wide range of animal and landscape imagery.
—People: Nine of the 12 participants imaged childhood friends or important people from their past, "faceless" teachers, non-native drummers, unidentified faces.

- Out-of-Body Experiences (OBE) / Visitations
  Three of the 12 participants stated that they had the experience of leaving the module or being visited by a presence or a person during the session. This category is differentiated from "Journey" in that no traditional shamanic imagery was present.

- Non-ordinary or altered states of consciousness (ASC)
  A majority of the participants, in one or more sessions, were conscious of the fact that there had been a qualitative shift in mental functioning, and the 12 themes as synthesized from the participants' oral and written reports may be correlated with Ludwig's delineation of features that tend to be characteristic of most ASCs (Ludwig, 1968). Eight of the 12 participants experienced at least one episode that was a journey, OBE, or a visitation; the data suggests that they achieved an altered state of consciousness. There were a total of 13 such episodes for the 35 individual sessions.

This research seems to support the theories that suggest that the use of percussion by indigenous cultures in ritual and ceremony has specific neurophysiological effects and is associated with temporary changes in brainwave activity, which may facilitate imagery and entry into an altered state of consciousness. The tempo of each drumbeat used in this study, as it relates to beats per second, appears to be correlated with resulting temporary changes in EEG band power, provided the drumming pattern is sustained for at least 13–15 minutes.

The change is most prominent at minute 9, most notably for theta and alpha waves. According to field observations and subjective reports, the period of time required for most individuals to be affected/inducted by ritual drumming appears to be 13 to 15 minutes (Cade & Coxhead, 1979; Achterberg, 1981; Benson, 1980, 1984; Murphy & Donovan, 1988). This observation echoes the oral teachings of some indigenous cultures concerning auditory stimulation (Arrien, 1989).

Our data showed a rapid increase or diminishment of theta and/or alpha to the 15-minute point, with a gradual gain or diminishment on to the 20-minute point (Figures 2.1, 2.2, 2.3). The drumming pattern most often associated with increased theta wave activity was 4 to 4 1/2 beats per second, or the typical drumming tempo observed in shamanic work. Seven of the 12 participants showed varying degrees of increased theta during the shamanic drumming (Figures 2.2 and 2.5).

Finally, subjects "set and setting" are important, and any replication attempts should keep this in mind. By closing the subjects in a sound-proofed, light-proofed chamber, in a comfortable lying position with their eyes closed, there was an attempt to replicate the postures and conditions typical of the indigenous ceremonies at issue. It seems likely that both the indigenous environment and that in the lab helped participants focus their attention as completely as possible on the auditory stimulation. It also seems intuitive that driving is dependent on the attentional state of a subject: that wandering attention would prevent driving from taking effect, though this cannot be determined from our study. The length of the sessions, almost an hour in total, including baselines before and after the period of stimulation, may also have contributed to the relaxation and attentional processes of the participants. In sum, these factors were likely significant in the successful replication of ritual conditions: not only was an EEG driving response recorded, with concomitant elevations in alpha and theta band power, but the subjective data indicated that participants did indeed undergo a change in state of consciousness.

PART II. EFFECTS OF RHYTHMIC CHANTING ON HEART RATE AND RESPIRATION

Physiological rhythms are hierarchically organized. One rhythm we can (at least partially) control is breathing. However, due to the hierarchical organization of respiratory system, conscious control of breathing influences other physiological rhythms. For example, breathing influences the most prominent component of heart rate variability, Respiratory Sinus Arrhythmia (RSA) (Heart Rate Variability, 1996; Ray et al., 1999; Jovanov, 2005). Rhythmic breathing has prolonged effects on RSA and generates resonance-like effects on heart rate variability (Lehrer et al., 1999; Vaschillo et al., 2002). Very slow yogic breathing has a similar effect (Jovanov, 2005). A typical example of heart rate variability before and after a slow breathing exercise is presented in Figure 2.7. It can be seen that before the breathing exercise the subject exhibits bursts of very regular RSA; for example, regular sine-wave-like bursts of RSA at time 50 sec and 120 sec. During this time, heart rate variability perfectly follows instantaneous lung volume. After the breathing exercise (at time 1050 sec), the subject exhibits a very regular RSA pattern as seen in the lower plot. However, it can be seen that even during the preparation period the RSA pattern becomes very regular as a result of years of exercise and conditioning.

Rhythmic chanting can be seen as a devotional practice that synchronizes the hierarchy of a subject's bodily rhythms and strengthens the coupling between them. Therefore, during this practice we can expect to see an increased interaction of breathing and heart rate variability, or a larger amplitude of the RSA. An example can be seen in Figure 2.8. The upper plot represents heart rate variability at the beginning of chanting, whereas

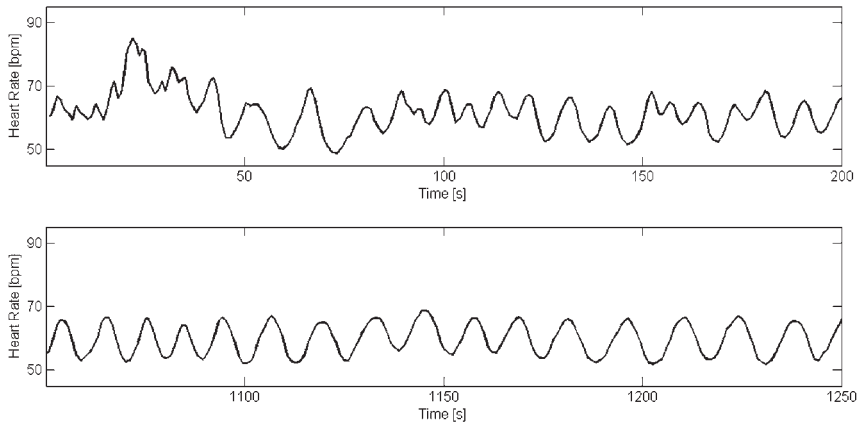

Figure 2.7 The effect of very slow yogic breathing (1 breath/min); heart rate before (upper) and after (lower) this slow breathing exercise (Jovanov, 2005). Heart rate in beats/minute is represented as a function of time in seconds.

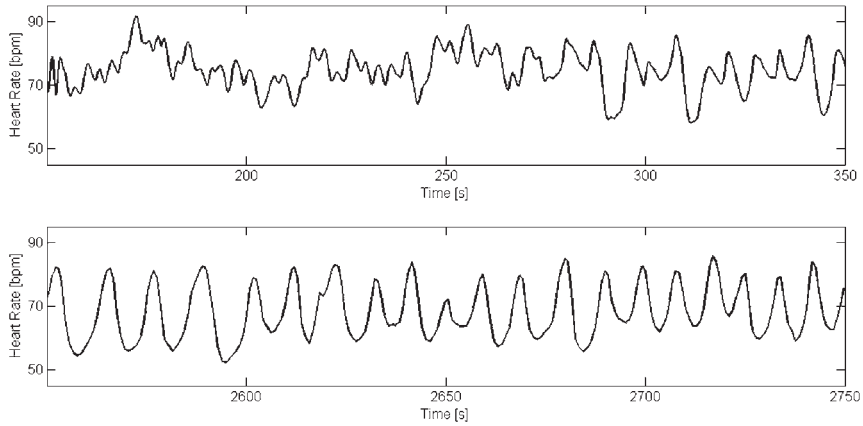

Figure 2.8 The effect of rhythmic chanting, at the beginning of trial (upper plot) and 45 minutes later (lower plot). Both plots represent heart rate in beats/minute as a function of time in seconds.

the lower plot represents the variability of the same subject after 45 minutes of chanting. A rhythmic, regular pattern of inter-beat variability can be clearly seen on the lower plot.

We believe that the stabilization of basic physiological rhythms may serve as a foundation for higher states of consciousness (Jovanov, 1995; Rakovic et al., 1999). The role of the limbic system is crucial for survival, since it makes possible the high priority body activation necessary during times of crisis. However, during these times, this activation influences certain mental content in our flow of thoughts. This results not only in a

change in our conscious state, but in the processing of conscious material. As we cannot consciously and directly control the functions of our limbic system, we cannot directly control our stream of consciousness.

We hypothesize that externally stabilized physiological rhythms can result in periods of uninterrupted conscious experience via the indirect stabilization of the limbic system via practices like chanting or controlled breathing. This stabilization (described experientially as "stillness" by many meditators) can allow deep insights and a variety of integrated experiences to emerge (Iyengar, 1993). To paraphrase a frequently used metaphor: You can hardly see deep into the water when there are tumultuous waves on the surface; however, when the water becomes still, you can see all the way to the bottom.

DISCUSSION AND CONCLUSIONS

To understand more about the relationship between these stimulation techniques and their reported effects, much more clinical research is needed, using the combined efforts of scientists, psychologists, ethnomusicologists, and anthropologists. Naive participants, some having had prior preparation, as well as subjects who are familiar with and have been trained for various types of ASCs, should be tested. Brain electrical activity and autonomous nervous system activity should be monitored. Natives who are indigenous to a culture which still holds to and honors the traditional aspects of drumming as an integral part of ritual and ceremony should be tested in a laboratory using recordings of the actual ceremonial drumming of their culture. These results could then be compared to the results of naive and non-naive subjects. Research involving live drumming should be carried out and then compared to taped drumming.[3] It would also be interesting to simultaneously monitor subjects and drummer(s) to observe common patterns and synchronicity of changes. As the technology becomes available, the use of mobile EEG could prove to be crucial to the study of these ritual techniques in context. We hypothesize that the entrainment techniques such as rhythmic drumming, stabilize and regulate basic body rhythms, which has therapeutic value in itself (see Connie Tomaino's comments in Chapter 6), and allow transcendent experiences to emerge. We hypothesize that these entrainment techniques provide extended control of the limbic system, offering one the chance to reduce emotional noise and settle the mind.

ACKNOWLEDGMENTS

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NOTES

1. In the fall of 1986, as a graduate student in a course on core shamanism, Dr. Maxfield experienced her first "drum journey." Unaided by drugs, she experienced vivid visual and somatic imagery, incorporating classic shamanic and archetypal themes. She was surprised and intrigued. She hypothesized that she was entering into an altered state of consciousness of some kind, related to, but not the same as, a meditative state. If this were so, then, she hypothesized, the nature of this experience could be better understood by measuring the electrical activity of the brain with an electroencephalogram machine (EEG) during such a ritual. Three years later, she began her research to determine whether various drumming patterns would be associated with different brainwave activity, as measured by cortical EEG, and to determine if the subjective experience of percussion in general, and rhythmic drumming in particular, would elicit images or sensations with a common theme.
2. In research on imagery, meditation, and relaxation techniques with inexperienced practitioners, it is a common observation that maximal optimal physiological response occurs within the first 10 to 15 minutes of stimulation, after 25 minutes a diminishing return transpires (Benson, 1984; Cade & Coxhead, 1979; Murphy & Donovan, 1988).
3. The experience of listening to drumming through headphones or small speakers is vastly different from feeling the vibrations of a live drum played in front of you. Monitoring the rhythmic bass vibration/tactile elements of drumming could be a critical addition to future experiments on entrainment to percussion.

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