EEG responses to shamanic drumming. Does suggestion of trance state mediate the strength of frequency components?

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One of the techniques used to induce trance state in shamanic ceremonies is monotonous drumming. According to previous EEG research, certain patterns of drumming cause an increase in power of alpha and theta frequencies of the listener. Present study aimed to determine, if suggestion to experience trance state could increase the relative alpha and theta amplitude and the intensity of experienced state. A group of twenty-four subjects participated in the study. Suggestion to experience trance state decreased alpha frequency power during the drumming condition. No other significant effects of suggestion or drumming were found.

The key concept in shamanism is the ceremonial use of the state of trance (Eliade, 1964). Altered consciousness may be achieved in various ways, either ascetic, like meditation or sensory deprivation, or ecstatic, such as dancing, chanting or use of entheogenic substances. A very popular instrument used in ceremonies is the drum, and monotonous patterns of drumming are often used to induce a state of trance.

One of the first scientific experiments on the physiological effects of drumming was done by Andrew Neher (1962). His study was inspired by the similarities in the response noticed between drumming ceremonies observed in the field by anthropologists, and the effects of rhythmic stimulation observed in laboratory studies (Adrian, Matthews 1934). During ceremonies, unusual perceptions and hallucinations were reported, as well as twitching of the body and generalized convulsions.

Early laboratory examinations of responses to rhythmic stimulation used mainly visual stimulation in the form of a flashing light. Several studies used auditory stimulation, with little effect at this time (Goldman 1952). Neher claimed that the clicks and single tones provide a different, less complex stimuli than a drum, every beat of which contains a wide spectrum of frequencies. Different sound frequencies are transmitted along different nerve pathways in the brain, therefore a larger area of the brain is being stimulated. He also hypothesized, that the low frequencies of the drumbeat transmit more energy to the brain than the high frequencies, which can be painful or damaging due to the delicate structure of our receptors.

Since 1934 (Adrian & Matthews 1934) it has been known that rhythmic visual stimulation in the form of flashing light with a frequency close to the alpha rhythm of the brain can produce two effects in the EEG: (1) The EEG increases in amplitude and (2) if the frequency of the light
flashes changes, the brain wave rhythm changes to that frequency. This phenomenon is called photic driving (Neher 1962).

Based on these facts, Neher expected that an auditory stimulus frequency between 8 to 13 cycles per second should also be the most predominant in ceremonies that induce “unusual behavior” and hallucinations. His expectations are supported by the anthropological research he cites, which reports the use of drum beat frequencies between 7 and 9 or between 8 and 9 cycles per second in ceremonies in Africa or in the Vodoun cult in Haiti (Neher, 1962).

To this end, Neher used two sound stimulus conditions: (1) four sequences of three, four, six and eight cycles per second, each sequence consisting of forty seconds of stimulation followed by 40 seconds of rest and (2) four minutes of continuous stimulation at four beats per second. In all subjects there were driving responses recorded, similar to photic driving. The main area of driving was the auditory cortex, with some recruitment in other areas, particularly the occipital cortex.

Nehers observations can be treated only as preliminary. The duration of the stimuli was far too short to determine if observed effects were the result of drumming, and the number of participants was very small (N = 10). However, his study was an important point of departure for further research on trance-inducing drumming. Maurer et al (1997) aimed at comparing the trance state induced by monotonous drumming with that induced by hypnosis. In that study, a group of 206 participants experienced a session of 15 min monotonous drumming with 3 beats per second, before or after the administration of the standard hypnosis induction according to the instructions from the Harvard Scale.

The participants also completed a Phenomenology of Consciousness Inventory, in order to
assess their subjective experience during the last 4 min of the drumming session. The reports were categorized into: (1) negative experiences, (2) neutral experiences, (3) relaxed experiences and (4) shamanic experiences (visions with content usually ascribed to shamanic experiences). Forty participants reported negative experiences, 41 neutral, 43 relaxed, and 45 shamanic.

There was a significant association between the type of experience and the stimulus order. A significantly larger portion of student reported negative or neutral experiences when the drumming session was done after the hypnosis. There was also an association between individual traits and shamanic experiences. The people who had shamanic experiences during the drumming session came largely from the groups of medium or high hypnotic susceptibility scores (Maurer et al 1997).

A more direct way to assess trance or altered states of consciousness is to measure patterns in the electrical activity of the brain. The electroencephalograph (EEG) provides information about neural oscillations. The frequency components of the neural oscillations spectrum allows to detect for example states of alertness (beta brainwaves), relaxation (alpha brainwaves) or drowsiness (delta brainwaves).

Maxfield (1990) examined EEG recordings as a function of various drumming patterns. Maxfield aimed at determining, whether different drumming patterns would have different effect on cortical EEG. Twelve participants listened to three different recordings: 1) shamanic drumming, with 4 to 4.5 beats per second, 2) I Ching drumming, with 3 to 4 beats per second, and 3) free drumming without a sustained pattern. In addition to the measurement of EEG recordings from four cortical sites, every participant had to write a brief description of his/her subjective experience. For an efficient interpretation of acquired data, from each of the three
experimental conditions, five epochs of one minute were chosen, from which the general mean scores and standard deviations of alpha, beta and theta brainwaves for each participant were calculated, and compared with the baseline condition during which participants listened to white noise. The chosen epochs were: (a) after 2 minutes of listening – after initial “settling in”, (b) at 9, 13, and 15 min, as the optimal physiological response should occur and (c) after 20 min to determine if the amplitude of these frequency components decreased or increased after the stimulus ended.

The results of Maxfield’s experiment suggest that different patterns of drumming lead to different changes in brainwaves. The drumming pattern with 4.5 beats per second elicited the strongest increase in the theta component, probably because of the photic driving phenomenon that mirrors theta frequency of 4 to 7 cycles per second. During this pattern were also the largest increases in alpha and beta recorded, whereas the I Ching drumming elicited only a weak theta increase. During free drumming, without any sustained rhythm no significant increases in any bandwidth were found.

Apart from the EEG recording, written descriptions of subjective experiences were collected from the participants. These were categorized, according to common themes and topics, into experiences of: (a) lost time continuum participants stated, that they lost track of time and did not know how long did the session last (b) movement sensation, experience of flying or distorted body image (c) feeling of becoming energized (d) discomfort – mental or physical (e) feeling of leaving the body (f) shamanic imagery.

All participants experienced visionary experiences during at least one condition. The experiment supports the hypothesis, that rhythmic drumming can elicit specific
neurophysiological effects and induce state of trance (Maxfield 1990).

It is thus reasonable to believe that certain patterns of drumming induce states of trance due to the brainwave entrainment mechanism. However, it remains unclear if the mechanism is mediated by the expectancy of the effect. An important component of shamanic trance is the ritual. In Deep Listeners, Judith Becker (2004) emphasizes the ceremonial character and the group processes present in ritual, and suggests that it is not possible to isolate the experience of a singular participant from the cultural background of his experience. Pollak-Eltz, in a book about AfroAmerican cults, describes shamanic trance as “a mixture of autosuggestion and conditioned reflex” (as cited by Cerulli, 1975) A parallel can be drawn between shamanic trance and hypnotic trance, and expectancies are therefore likely to influence hypnotic experience.

Expectancies can shape the ability to resist suggestion, and can influence hypnotic suggestions, such as arm catalepsy, or spontaneous amnesia (Accardi et al., 2013). Prätzlich et al (2015) examined, whether expectation mediates the effect of short meditation on executive brain functions. Both positive and negative verbal suggestions were used. Positive expectation group were informed about enhanced attention abilities after meditation. Negative expectation group received information, that although in the long run meditation enhances attention, when attention is measured right after the practice the performance is impeded by the mental exhaustion of the practitioner. The results of the study indicate, that expectancy can influence Stroop interference control, and may also mediate the effect of meditation on verbal flexibility.

While Maxfield noted increase in alpha and theta as a function of both the type of drumming and the experienced state of trance, one may wonder, how big were the effects of the expectation and of the drumming itself. In California, shamanism based therapies are much more popular,
which may have caused the participants to be better acquainted with the idea of inducing trance by drumming, and therefore a part of the observed effect may be due to the participants knowing what should happen.

Although in the Maxfield study during three different experimental drumming conditions both EEG recordings and brief descriptions of the subjective experience were gathered from the participants, no relation between those variables was measured. It is possible, that pattern of drumming with 4 beats/s induces increase in theta and alpha, and that used pattern of drumming explains the experience of trance state reported by the participants, but a question that still remains unanswered is whether there is any correlation between the size of observed increase in EEG amplitude and the intensity of the trance experience.

The type of participant feedback chosen by Maxfield provides us with general information about their subjective experience during the sessions, but because no standardized questionnaire was used, it is not possible to infer if there was any relation between EEG records and the intensity of subjective experience. A later study by Maurer et al. (1997) used Phenomenology of Consciousness Inventory (PCI) developed by Pekala (1991), but unfortunately no EEG data was collected.

Research objectives

The aim of the experiment was to contribute to the existing scientific knowledge about shamanic drumming, and provide answers concerning the possible effects of expectancy on the trance experience, while at the same time avoiding methodological problems present in previous research on the subject. Out of the very limited scientific literature about shamanic drumming, only two studies used EEG to examine the trance state induced by monotonous drumming
(Neher, 1962, Maxfield, 1990). Furthermore, one of them showed major methodological flaws.

One of the aim of the experiment was to determine, if the results obtained by Maxfield and by Neher could be replicated.

Another objective was to examine the possible mediating role of expectation in experiencing trance state during listening to drumming. Verbal suggestions were used for example in a study by Prätzlich et al (2015), which results indicate that such manipulation may mediate the effect of meditation on executive brain functions. Similarly, it was expected that the suggestion may influence participants ability to experience trance state during drumming stimulus.

The third aim of the experiment was to find out if the changes in the EEG frequency, as observed by Maxfield and Neher, are related to the intensity of the experienced state of altered consciousness.

Based on these research objectives, three scientific hypotheses were derived: (1) The suggestion to experience trance state will increase the relative amplitude of theta and alpha. (2) The suggestion to experience trance state during drumming will increase the intensity of subjective experience, as measured by PCI. (3) The theta and alpha amplitude will increase with the intensity of the experienced state, as measured by PCI.

Methods

Participants

A group of 24 people participated in the experiment consisting of 13 males and 11 females (M age=28.8 SD=8.05). The group was recruited mainly among Umeå university students and members of Yogasällskapet yoga center. All participants lived in Umeå, twenty of them were of
Swedish origin and all of them were fluent in English. The inclusion criteria were normal hearing and no prior experience with shamanic drumming. Exclusion criteria was epilepsy and psychosis. To ensure a normal state for the EEG procedure, all participants were asked not to drink alcohol or use drugs the day of the session and the day before. They were also advised not to come on empty stomach and not after a big meal.

Sound recording

To produce a recording for the experiment, an accurate replica of shamanic frame drum was constructed, with wooden frame and deer hide membrane. Samples of drumming with the pattern of approximately 4 beats per second were recorded. The pattern was chosen basing on previous studies, and commercial shamanic drumming recordings. Using Ableton Live 9 software, the chosen sample of 1.5 min was looped to produce a recording of steady 15 min of drumming. Beginning and end of the each sample repetition were adjusted to make the transition unnoticeable. A small reverb effect was added to the recording to create the feeling of listening to the drum played in a room. The samples were not corrected to achieve a metronomically perfect 4 beats/second speed, to simulate a live performance during a shamanic ceremony. The beginning and end of the recording were faded to create a smooth transition between the drumming and the control conditions: in the beginning the sound level increased up to the basic level for 10 s, and in the end the sound decreased for the last 10 s. Recordings similar to the one used in present experiment can be found on Youtube, as seen in a video by Adam Biacsi (2015), or by shamanismireland (2014).

Instruments

An AD Instruments Powerlab 8/35 device with a Dual BioAmp amplifier was used to collect
the EEG data, together with five Ag electrodes (impedance < 5kΩ) (Will & Berg, 2007) and AD Instruments LabChart 8 software. Two balanced input channels were utilized. Channel 1 gathered signal from the occipital lobe as the main source for alpha frequency bandwidth. The first electrode in this channel was placed on the occipital lobe (IZ), and the reference electrode was placed on the parietal lobe (TZ). Channel 2 gathered signal from the temporal lobe, with the first electrode placed on the left temporal lobe (T7), and the reference electrode placed on the right temporal lobe (T8). This setting of the channel 2 was chosen in order to detect theta signal if it would occur. An additional grounding electrode was placed on the forehead. The sampling frequency was 1000 Hz, and the time resolution 1 cm/s. A mains filter was applied to exclude 50 Hz interference and a 50 HZ low pass notch to cut off high frequency noise. With these placements of the electrodes far away from the forehead no means of correction for eye movement artifacts were needed.

The Phenomenology of Consciousness Inventory (PCI) is a self-rating instrument developed to measure subjective experience during altered states of consciousness, such as hypnosis, OBE or various types of meditation. The PCI was used to measure the subjective experience of drumming by Maurer et al. (1997). The PCI is designed to be completed after a short stimulus condition and contains 53 items that cover 12 major and 14 minor dimensions. These include: internal dialogue, self-awareness, altered state of awareness, imagery, positive affect, sexual excitement, love, negative affect (anger, fear, sadness), altered experience, body image, perceptions, unusual meanings, attention (absorption, direction), memory, rationality, volitional control and arousal (relaxation). The testing of the questionnaire indicate, that its dimensions and subdimensions are stable constructs, and its reliability and validity satisfactory (Pekala, 1991).
Procedure

Prior to the session, participants were informed that during the experiment they will relax and listen to shamanic drumming. All experimental sessions were done in the afternoon to control for the time of the day. During two weeks, two experimental sessions were done at 16.00 and 17.30, one participant at a time. All sessions took place in a calm, quiet laboratory, and the time of the day was chosen to limit the amount of possible outside noises. At arrival in the laboratory, participants were advised to use the toilet if needed before the session. Every session started with signing the consent form and reading the informational text – neutral for Group 1, and a text containing suggestion for Group 2. After signing consent and reading the text, participants were informed about the procedure of the experiment. They were asked to relax and keep their eyes closed throughout the recording, and to move as little as possible, but also to adjust their position whenever they feel uncomfortable. They were also instructed to continue lying still and relaxing after the drumming track will end, until the experimenter informs them that the recording is over. Subsequently, EEG electrodes were glued onto the chosen places on their scalp, and sample recordings were done to ensure the quality of the signal and adjust the placement of the electrodes if necessary. After obtaining steady signal, participants lied down on a bed, and put on a headphone set. The headphones were not removed until the end of the recording, to shield the background noise. After the participants got a comfortable position and stopped moving, the recording started.

First, 10 minutes of baseline control condition was recorded. Data from the first five minutes of the control recording were treated as an adaptation period and were excluded from the analysis. After the first control condition, the drumming track was played through the
headphones. Subsequent to the drumming condition, second control recording was taken, to provide additional baseline and to allow determining if the drumming stimulus would elicit changes in the EEG signal delayed in time. After the end of the recording, the electrodes and headphones were removed, and the participants completed the PCI questionnaire.

**Design**

Participants were randomly assigned to two groups. Group 2 received a suggestion in form of a written text before the experiment, whereas group 1 received no suggestion (they were given a neutral text). **Group 1** received a neutral text. It referred to the drumming, but no trance state effects were mentioned.

“Drumming if often used in native ceremonies. It is sometimes combined with singing or playing other instruments, like rattles or flutes. During the experiment, you will hear drumming on an exact replica of the drum typically used during such ceremonies, with a deer rawhide membrane mounted on a wooden frame using traditional methods. The drum is usually beaten with a stick with a steady, monotonous pattern. No other instruments were used in the recording.”

**Group 2** received a text containing a suggestion that they may experience a trance state during the drumming.

“Rhythmic drumming is used in shamanic ceremonies to induce a state of trance. During the altered state of consciousness caused by drumming you may feel either energized or relaxed. Your body experience often becomes distorted, and you may feel pressure, expansion or vibration in various parts of your body. It is also common
to experience sensations of movement: flying, falling, or spiraling. Usually, your imagination gets very vivid, and you may experience visions or a dreamlike state of mind. Participants of shamanic drumming ceremonies often describe their experience as a “journey” emphasizing the sensation of distorted time and space, and a feeling of leaving the body and traveling.”

Data analysis

Statistical analyses were conducted using AD Instruments LabChart 8 and LibreOffice Calc software. From the first control condition, the first five minutes were ignored as adaptation time, and the epochs starting 5, 6, 7, 8, and 9 minutes into the recording were chosen for further analysis. From the drumming condition, epochs starting 8, 10, 12, 13, and 14 minutes after the drumming begun were chosen. From the second control, epochs starting 2, 4, 6, 8 and 9 minutes into the recording were chosen. No visible movement artifacts were noticed in the chosen epochs. From the LabChart spectrum view, the data for the chosen epochs were derived. Fourier Transform was used to derive the power of each frequency component from the raw EEG signal. Alpha peak was the highest amplitude density in the 8-12 Hz frequency range, and delta peak was the highest amplitude density in the 0-4 Hz frequency range. For each chosen epoch, the mean peak values of alfa and delta amplitude density in μV/√Hz were derived for the further analysis.

The experiment used one between subjects factor: suggestion and neutral text groups and two within-subjects factors: three conditions and five epochs in each condition. Therefore, to determine if suggestion increases the relative amplitude of frequency components a two groups x 3 conditions x 5 epochs repeated measures ANOVA test was used.
Results

Preliminary observations of the EEG spectrum revealed that there were almost no theta components in the EEG signals. Two peaks corresponding to alpha and delta bandwidth were clearly noticeable for all participants, and the subsequent analyses were therefore conducted on these.

Examining the mean amplitude values from both channels led to the observation that the power of the alpha component was stronger in Channel 1 (occipital lobe), whereas the power of the delta component was stronger in Channel 2 (temporal lobes). Therefore, Channel 1 was chosen as the source of alpha data and Channel 2 was chosen as the main source of delta data.

Figure 1 presents means and confidence intervals for all the participants. Differences between the participants were very large.
I first address the hypothesis that the suggestion to experience trance state increases the relative amplitude of theta and alpha. Two 2 group x 3 condition x 5 epochs repeated measures ANOVA was performed to reveal any significant differences in mean alpha and delta amplitudes as a function of suggestion and condition. There was a significant main effect of epoch ($F_{4, 24} = 11.67, p < .01$), but there was no significant main effect of suggestion ($F_{1, 24} = 0.81, p > .05$), and no significant main effect of condition ($F_{2, 24} = 2.71, p > .05$). There were no significant two-way interactions. However, there was a significant three way interaction between condition, suggestion, and epoch ($F_{8, 24} = 2.19, p = .031$). For delta, no significant main or interaction
effects were found (suggestion $F_{1, 24} = .01, p > .05$, condition $F_{2, 24} = .74, p > .05$), epoch $F_{4, 24} = 1.72, p > .05$).

Figure 2. Mean alpha amplitude density values across the conditions and epochs for suggestion and no suggestion groups.

Likewise the hypothesis that the suggestion to experience trance state during drumming increases the intensity of subjective experience (measured by the PCI instrument) was falsified. An independent t-test found no statistically significant difference between suggestion and neutral group in the Altered Experience (AE) scores ($p > .5$).

Finally, the hypothesis that theta and alpha amplitude increase with the experienced intensity
AE was addressed with two different analyses. First, the participants were divided in two groups based on their Altered Experience (AE) scores. The AE is a major scale of the PCI questionnaire measuring to what extent the experience was different from ordinary state, therefore allowing assessment of the intensity of trance state. The mean score for the whole group was 2.45, and those with a lower score than this (N = 13) were compared to those with a higher score (N = 11). One Way ANOVA test showed significant differences between the groups in terms of alpha scores during drumming (p = .018). Delta differences during drumming were not significant (p = .09). Correlation analysis showed no significant correlations between AE scores and frequency component scores.

Discussion

The experiment indicate that drumming did not affect theta activity, and that it decreased alpha activity, both results being at variance with the hypotheses and the results of the Maxfield study, although a similar drumming pattern was used. In the suggestion group, a lesser alpha during the drumming condition was registered, which also stands in opposition to the conclusions of Maxfield’s, who noted an increase in alpha during drumming. This situation of similar stimuli yielding different EEG results indicates that shamanic drumming is a complex phenomenon requiring further scientific investigation. It is possible that there are other variables than merely the amount of beats per second that determine the trance-inducing character of the drumming. Typically, different combinations of strong and weak drum strokes are used during drumming. Future research would benefit from comparing patterns of drumming with the same speed of beats per second, but different combinations of accents.

One of the possible reasons for the differences in alpha activity between the present and the
Maxfield study may be different placement of the electrodes. In the present study, the occipital location for Channel 1 electrode was chosen due to the fact that the occipital lobe is the main source of alpha activity. The electrodes in the Maxfield study were placed at the left parieto-central, right parieto-central, left parieto-temporal, and the right parieto-central areas, which means that the main source of alpha signal was not monitored. Many of the participants reported that the drumming had a very relaxing effect, which is additionally supported by low scores on the Arousal (AR) scale of the PCI questionnaire. The decreased alpha in the suggestion group may be connected to the greater relaxation of those participants.

Another possible explanation for the different results compared to previous studies could be cultural differences. Both Maxfield’s (1991) and Maurer et al.’s (1997) experiments took place in the USA, whereas a majority of the people who participated in the present study were Swedish. Due to the popularity of New Age and alternative medicine, shamanism is much more culturally present in the US than in Sweden. Although Sweden also has a long tradition of Saami shamanism, with a particularly strong rite of drumming, shamanism is no longer openly practiced or discussed here. In the present study, the cultural differences were visible in the reactions of participants to the PCI questionnaire. Participants had difficulties understanding some of the questions connected for example with expanding of the body or visionary states and imagery. It may mean, that they are not used to describing their experience in such terms. Cultural differences may also limit the effectiveness of suggestion. In other words, Swedish people may be unlikely to believe, that they will experience a state of trance. For future research on shamanic drumming it would be reasonable to adjust the used instruments to the cultural background of the participants.
One of the important aspects of the present experiment was the horizontal position of the participants. During shamanic ceremonies, participants are sometimes lying down as well, but in many indigenous rites involving drums movement and dance are used, creating much complex stimulus. Due to the problem of movement artifacts, replicating such conditions was not possible in EEG study. Remaining in horizontal position throughout the session allowed obtaining steady EEG signal from the participants, but might have increased their drowsiness.

Worth mentioning is also the obvious difference between listening to the recording of the drumming from headphones, and listening to the live performance. Although recording the sound makes it possible to present the exact same stimulus to all the participants, it limits the richness of the experience.

**Limitations**

One of the limitations of the present study was a heterogenous group of participants. The age span was very wide, ranging from 20 years for the youngest participant to 43 for the oldest one, which may have increased the individual differences in EEG signal between the participants. EEG signal is very sensitive to specific state of the participant, and older people may respond differently to remaining in horizontal position for a prolonged time. The increased variance in EEG signals may be the cause of reduced statistical power, and therefore insignificant results. Moreover, nine of the participants were recruited from the Yoga studio were the present author used to teach. Some of the participants recruited from this source had experience with meditation practice, which tends to be associated with higher baseline alpha activity (Cahn & Polich, 2006). People practicing meditation are more likely to enter a meditative state during the experiment, which would yield different EEG responses during both drumming and control conditions. This
would decrease the difference in EEG signal between drumming and control conditions, therefore making it statistically insignificant. Finally, even not having prior experience with shamanic drumming, they are more proficient in controlling their state of awareness, which may make them respond to drumming differently. It may be reasonable for the further research on shamanic drumming to control for the meditative practice.

In conclusion, suggestion about experiencing a state of trance might decrease alpha frequency brainwave activity when listening to shamanic drumming, which indicates a deeper state of relaxation, rather than the predicted trance state. The experiment did not replicate the results of the previous studies, which indicates that the phenomenon of trance induced by shamanic drumming is not well understood.
References


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