

Sonic Patterns, Spirituality and Brain Function: The Sound Component of Neurotheology

Donald R. Hill^{*†‡} and Kevin S. Saroka^{†‡}

Abstract

Sounds found at 'sacred sites' marked by art-rock have been reported to induce altered or mystical states. To determine the neural correlates of these sounds we measured brain activity with a quantitative electroencephalograph (QEEG) while they listened to a binaurally-recorded soundscape derived from one of these locations. We found that the soundscape increased frontal gamma activity, enhanced coherence between the left temporal and right frontal regions, and modulated cingulate activity within the alpha, beta and gamma bands. These results demonstrate that the "sacred" effects of certain patterns of sounds may have a neurobiological basis and can induce configurations of brain function that are associated with altered or mystical states.

Key Words: sound, altered or mystical states, coherence, quantitative electroencephalography, cingulate cortex

NeuroQuantology 2010; 4: 509-516

Introduction

Traditional cultures have been known to use sound to bring about altered states (Mezner, 1987). Drumming, chanting, vocalization and the playing of musical instruments have been reputed to be healing agents with 'curative powers' (Hoppal, 2006; Neher, 1961). Theosophical literature, such as the volume *Thought-Forms*, was steeped in theories concerning the fourth dimension and how vibration and mystical sounds and mental phenomena associated with emotive musical compositions are manifest in present-tense reality (Besant and Leadbeater, 1901).

The claims that sound may have therapeutic utility may have a biological

basis. Studies investigating the effects of music on brain function using quantitative EEG (QEEG) have demonstrated that the perceived pleasantness of a musical piece will differentially affect the left or the right hemisphere (Schmidt and Trainor, 2001). In keeping with general functionality of the two hemispheres, pleasant music is associated with activation of the left hemisphere while unpleasant music is associated with activation of the right hemisphere (Henkin and Levy, 2001; Turhan, 1998). Thus individuals who show a propensity for right hemispheric laterality, which is associated with depression, might benefit from listening to pleasant music that activates the left hemisphere to reduce the magnitude of the asymmetry. In fact it has been reported that subjective symptoms of depression in Benedictine monks were alleviated after they were re-permitted to engage in ritualistic Gregorian chant (Tomatis, 1991).

Appropriately patterned sound has also been demonstrated to induce meditative states, specifically when binaural beats are presented to both ears. The general

Corresponding author: Donald R. Hill

Address: *Liberal Studies, Faculty of Extension, University of Alberta, 2-200 Enterprise Square, 10230 Jasper Ave NW, Edmonton, Alberta Canada T5J 4P6, email: hilldon@telus.net; †Behavioural Neuroscience Program and ‡Department of Psychology, Laurentian University Sudbury Ontario P3E 2C6, email: ks_saroka@laurentian.ca

Thanks to Dr. M. A. Persinger for technical comments.

e-mail: hilldon@telus.net

Submitted for Publication: Oct 20, 2010; final revision received Oct 25, 2010; accepted Oct 26, 2010.

mechanism involves entraining the brain such that a beat frequency, which is the difference between two frequencies presented to each ear, ultimately produces coherence between the left and right hemispheres. This coherence may produce the conditions for altered states. It has been reported that meditators who were exposed to hindering binaural beats showed enhanced theta activity over the occipital lobes (Lavalley, Koren and Persinger, 2010), suggesting that mediators are not influenced by stimuli designed to disrupt meditation. Increased occipital theta was also observed in a subject who demonstrated remarkable abilities for remote-viewing (Persinger *et al.*, 2002).

The first author has been investigating sounds found at special places that are designated as 'sacred'. These sites often contain 'rock art' in the forms of pictographs, petroglyphs and petroforms. The sounds, which have been described as **repetitious**, produced at these specific sites, have been reported to **create trance and meditative states**. Sound that has **cyclic properties** has been proposed to place individuals into an **altered state of consciousness** (Satprem, 1964). **Prayer, meditation, and other rituals use recitation of repetitive stimuli to induce 'trance' or meditative states**. Certainly concerts containing minimalistic music (also labeled as **hypnotic, trance** or repetitive music) have been reported to induce trance-like states due to the repetitive characteristics of the music. Specific patterns of sound energy that **simulate intrinsic electrophysiological configurations within the brain** could entrain specific **cerebral functions** of both the **musicians and those of the entire audience**.

Indeed QEEG investigations employing simultaneous recording of the brain activity of two guitarists playing in synchrony show that the two brains become synchronized at approximately 4-5 Hz (Lindenberger *et al.*, 2009), **a central frequency of the theta (4 Hz to 7 Hz) band** that has been frequently associated with both **creativity and altered states**. The reported spontaneous experience of the "presence of God" and a state of "ecstasy" within the laboratory was reported by one accomplished female transcendental

meditator during the latter few minutes of a routine (about 15 to 20 min) meditation session. The experience was associated with theta spike and slow wave activity (Persinger, 1984). Increases in the **theta band have been demonstrated within the right temporal lobe of a receiver when two brains were simultaneously exposed** to the same magnetic field configuration (Persinger *et al.*, 2008). Given that the classic function of the **anterior temporal lobes is to process auditory information**, sound may serve as a unifying stimulus by which **multiple brains can be connected**.

We have pursued the possibility that mystical states are associated with the intrusion of one cerebral hemisphere into the other. Persinger *et al.*, (2010) have shown that two configurations of electroencephalographic coherence can discriminate between the sensed presence and the out-of-body experience (OOBE). Specifically the sensed presence is associated with an increase in coherence between the left and right temporal lobes while the OOBE is associated with increased coherence between the left temporal and the right frontal region.

That music and sound has the ability to 'transport' people into 'nonlocal' environments has been frequently reported and may suggest an OOBE-like cerebral process. Because music can be described as a series of pitches organized into a temporal sequence it's processing within the human brain would recruit several areas at once, much like language. Studies employing fMRI have demonstrated that, **depending upon the musical expertise of the listener, the rhythmic and melodic components of music will activate the left temporal and right prefrontal regions, respectively** (Parsons, 2001). Thus listening to music may create the conditions that promote left temporal and right prefrontal coherence and produce out-of-body-like experiences. There are myriad examples cross-culturally of variant descriptions that include "the soul travelling to distant places that exist now or in the past", "displacement to other dimensions", "transportation" to Paradise, Valhalla, Heaven, or the Neither World, and "visitations" with dead ancestors or spirit creatures.

We hypothesized that stimulation of the brain using sounds recorded at a 'sacred' location would facilitate the induction of altered and mystical states. Specifically we used binaural recordings of sounds found at this location in order to mimic natural human hearing. We hypothesized that in addition to observing increased left temporal-right frontal coherence that we would observe a concomitant increase in gamma activity (about 40 Hz). There is an intricate and functional relationship between the theta (4-7) range and gamma activity. For example 40 Hz ripples are superimposed upon the intrinsic theta activity of hippocampal patterns involved with memory consolidation and secondary retrieval. (Buzsaki, 2002). This simultaneity of these two frequency bands associated with both mesiotemporal lobe (hippocampus-amygdala) memory processes and cerebral cortically-mediated consciousness allows the representation of experience (memory) and awareness (consciousness) to intercalate (Holz *et al.*, 2010).

The specific association between the left temporal region and the right prefrontal cerebral cortices allows the interaction between the memory consolidation associated with the verbally (left hemispheric)-mediated sense of self and the reconstruction of experience primarily controlled by the right prefrontal region. Because the right prefrontal region is also associated with the spatial and social context in which these reconstructions occur, one would expect a significant component of the phenomenology to be related to spatial (and even temporal) references independent from the person's immediate locus and markedly influenced by his or her beliefs and imagination. Beliefs are self-organizations of the perceived operations of the external world as well as the expectancies associated with it. These beliefs are often "superorganic" in the sense they exist independent of the individual and are shared by members of a group because of the human being's dependence upon parental behaviors and their determination by cultural traditions.

We also hypothesized that there would be differential modulation of regions associated with attention due to the specific

order of the sound presentation. Like the understanding of language which is strongly affected by the order of phonemes or sound units that are presented to the listener, the temporal arrangement of patterns of sounds would be expected to amplify the "affective" and intrinsic meaning of auditory input. In a manner similar to the arousal boost and the arousal jag of the specific timing associated with the experience of humor, the timing of the primer and facilitator for a sequence of sounds based upon patterns that have been employed by cultures for millennia should produce systematic elevations in the cerebral activity that is associated with the "spatial displacement" types of neurotheological experiences.

Materials and Methods

Participants

We recruited 7 students (4 males and 3 females) between 20 and 30 years of age from the university campus to participate in the study. Each person was told that the study was to discern how ambient sounds, presented through headphones, affect brain activity measured by a quantitative EEG (QEEG).

Acoustic Presentation

The participants were presented with a soundscape recorded from locations in Canada designated as 'sacred' by Aborigines that was embedded in between tracks that were intended to relax and then to return the listener to a baseline state. The recordings were taken with a binaural recording device in order to imitate natural human hearing. As such the sounds are perceived in three dimensional spaces as opposed to 'within the head'. The total presentation of the sound stimuli was approximately 48 minutes and consisted of 5 tracks played consecutively (with 5 seconds of silence separating each track).

Tracks 1 & 2 consisted of an ambient surround of drones and triads of harmonic overtones made with metal 'singing bowls', chimes, bells, and lead crystal glasses, in order to habituate startle and allow the listener to relax. Track 3 consisted of a 30-minute binaural recording of a thunderstorm on a mountaintop. This track was hypothesized to induce an altered state because of the repetitive nature of the

sounds recorded at the site. Finally tracks 4 and 5 were introduced with the intent of returning the listener to a baseline state of consciousness. Specifically, track 4 was a binaural-head microphone recording of a professional cellist bowing the notes C and E together for just under 4-minutes. Track 5 was a stereo recording of a Tibetan Buddhist monk chanting harmonic overtones, which lasted approximately 2-minutes.

Data Acquisition and Analysis

Brain activity was monitored with a Mitsar-201 amplifier equipped with a 19-channel electrode cap. Each of the 19 sensors on the cap was attached to scalp with electrode gel. All impedances were kept under 5 kiloOhms. Data acquisition and eyeblink artifacts correction was completed with WinEEG software which sampled at 250Hz and was bandpass filtered for 0.5-30Hz.

Seven 10-second samples were extracted from the artifact-corrected record and represented, eyes-closed baseline and 10 seconds before the end of each song. Three analyses were completed using this data: spectral analysis, coherence and source. Spectral analysis and two coherence measures (left temporal-right temporal and left temporal-right frontal) were completed using Matlab software where both were computed within the delta (1 to 3.9 Hz), theta (4 to 7.9 Hz), low alpha (8.0 to 10.5 Hz), high alpha (10.6 to 13 Hz), low beta (13.1 to 20 Hz), high beta (21 to 35 Hz), and gamma (35.1 to 50 Hz) frequency bands. Further statistical analysis involving the derived spectral and coherence data was performed on SPSS software for Windows. Source localization was completed using sLORETA software. This software utilizes algorithms to detect changes in cortical activity across the classical frequency bands and has been demonstrated to be effective with as little as 19 electrodes.

Procedure

Each subject was tested individually. Upon explanation of the general procedure each participant was asked to sit in a comfortable arm chair that was housed into a sound-proof acoustic chamber. The electrode cap and the grounding sensors were attached, in accordance with the 10-20 International

Standard of Electrode Placement, and preliminary tests of QEEG acquisition were conducted. The participants were then fitted with Logitech headphones through which the sounds were played at a comfortable listening level. The chamber lights were turned-off and during the experiment the subject environment was dark. After an initial eyes-open and eyes-closed baseline the sounds were then presented while the QEEG continuously monitored brain activity.

Results

Subjective Reports

The participants reported various vestibular and visual effects in response to the sound presentation. Several participants indicated that the transition between Track 2 and Track 3 elicited a feeling as though they were being 'lifted', with concomitant tingling sensations. In addition participants indicated that they experienced scenic visualizations during the presentation of Track 3 and that they were watching a thunderstorm as it passed through their location. One participant indicated that he felt as though he was "on a rounded rock observing the clouds as the storm receded to the West where the sun could be seen". Tracks 4 and 5 were accompanied by somatic sensations as well as throat-clearing

Quantitative Results

Separate multi-level analyses of variance with 3 within-subject measures (condition, lobe and hemisphere) on the z-scored spectral data (to accommodate individual differences) for each frequency band indicated that there was a significant interaction between lobe and condition within the gamma frequency band ($F=1.47$, $p=.05$, partial $\eta^2=.20$). *Post-hoc* analyses employing paired t-tests revealed that the frontal lobes displayed significantly more gamma activity during the presentation of Track 3 compared to eyes closed baseline and Tracks 1,4 and 5 (Figure 1a).

As well, multilevel analyses of variance with 2 within-subject factors (coherence and condition) were also completed for coherence measures that had been transformed into relative changes from eyes-closed baseline. The analyses demonstrated that there was a significant

main effect for coherence type within the delta band ($F=5.96$; $p<.05$; partial $\eta^2=.50$) (Figure 1b).

Finally the results of the source localization analysis indicated that there was significantly more alpha activation ($p<.05$) at the end of Track 2 than for Track 3 (Figure 2a) within the cingulate region. The decrease in alpha during Track 3 was also accompanied by an increase in beta/gamma activity ($p<.05$; Figure 2b, c).

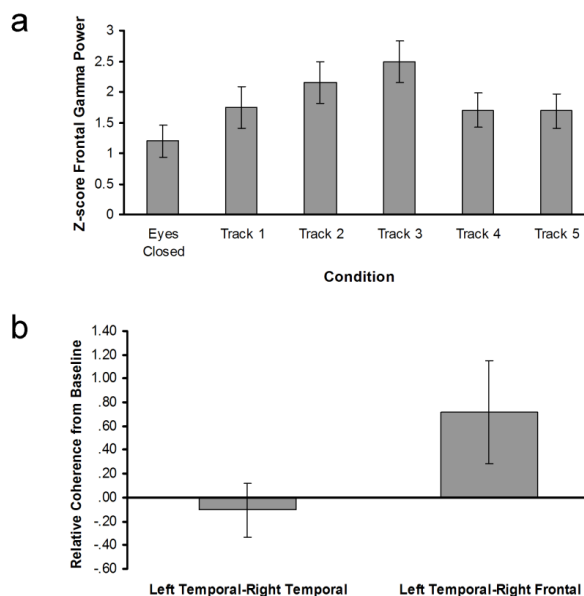


Figure 1. (a) Increased gamma activity within the frontal lobe during the presentation of Track 2 (chimes) and Track 3 (soundscape). **(b)** Increased generalized coherence in the delta band between the left-temporal and right-frontal regions when referenced to eyes-closed baseline.

Discussion

The experiment demonstrated that the induction of altered states might be accomplished by the appropriate application of sounds derived from ‘sacred’ places. Although the soundscape was a digital reconstruction, we attempted to maximize the authenticity of the experience by employing binaural-recordings. As such the sounds were perceived in three-dimensional space.

The temporal order in which the tracks were presented was crucial in eliciting the subject experiences reported during the experiment. Within traditions of classical

music symphonies, sonatas and other musical pieces are arranged by the composer to evoke certain responses from the audience at specific times within the performance. As such the arrangement of this soundtrack was intended to 1) relax the listener 2) induce an altered state and 3) return the listener to a baseline state of consciousness. The concomitant electroencephalographic profiles displayed by the participants as they listened to the soundtrack suggested the emergence of brain activity that would not only support the initial intent of this musical arrangement but may also suggest that the participants entered an altered state.

We observed an increase in frontal gamma power during the presentation of Track 3. This track, labeled "Fearless Fury", was designed by the first author to bring individuals into a similar state experienced during meditation. Lutz *et al.*, (2004) have demonstrated that experienced Buddhist practitioners showed enhanced gamma activity, particularly within lateral fronto-parietal comparisons, when they engaged in meditation. Thus, the original intent of the track, which was to induce a meditative state, may have been accomplished.

We also observed an overall increase in coherence between the left-temporal and right frontal regions relative to eyes-closed baseline, regardless of frequency band. This particular configuration of electroencephalographic coherence is associated with out-of-body experiences. Persinger *et al.*, (2010) have shown that an out-of-body experience, elicited with the application of a counter-clockwise rotating magnetic field, was associated with enhanced coherence within the left-temporal and right-frontal regions. Subjective reports accompanying the presentation of this track indicated that it induced visual scenes that changed progressively as a function of the sound. This finding may support the claim that “music takes people to places”. Whether the exact real space-time location of the recording was visualized by the participants cannot be verified through the present analyses.

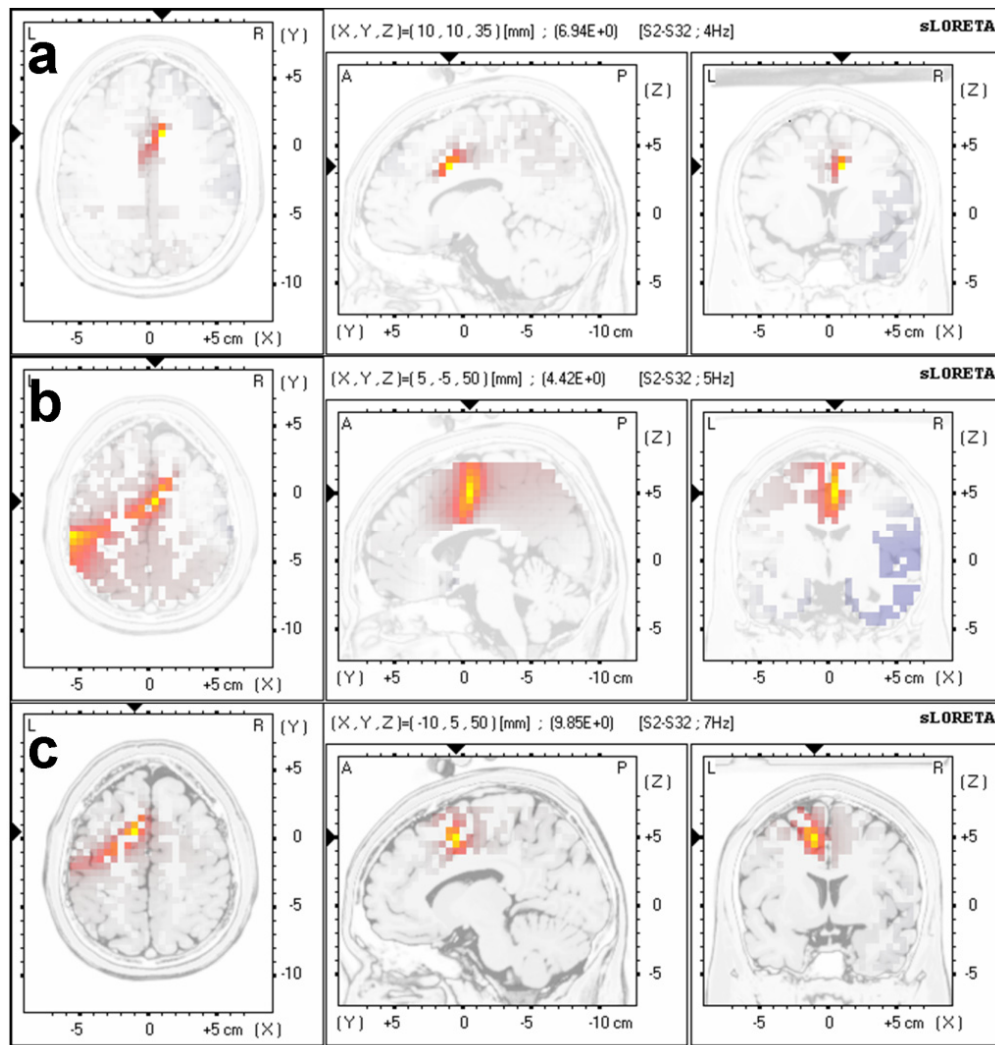


Figure 2. sLORETA images showing (a) Increased alpha within the right cingulate area during the transition between the second and third tracks (b) Increased beta activity in the right cingulate area and (c) increased gamma activity in the left cingulate region during the last 10 seconds of the soundscape recording.

The central role of regions within the prefrontal cortices of the right hemisphere in the retrieval of long term memory has been demonstrated with many experiments (Buckner and Petersen, 1996). Whereas retrieval, effectively reconstruction, of semantic memory involves the left prefrontal region retrieval of episodic memory which involves where and when and with whom events occurred, involves the right prefrontal area. This is the same region that is involved with spontaneous reports of events or pseudo-reminiscences (confabulations) that never occurred except through imaginal processes. However, they are experienced as real (Schnider, 2003). There is a general clinical consensus that transient metabolic anomalies or altered functions within the

organization of the right prefrontal region reduces the person's capacity to discriminate what actually happened from the images and representations of the verbal labels supplied by others or intrinsically applied by the experient (Fletcher and Henson, 2001). The imaginal experience appears a memory of an event that actually occurred.

Finally, source localization indicated there were selective increases and decreases at discrete points during the presentation of the sounds. Specifically, we observed an increase in alpha activity between Tracks 2 and 3. This might suggest that the listeners had relaxed and focused their attention internally. Mediators, who are known for directing their attention inward, display a decrease in activity within the anterior

cingulate (Lou *et al.*, 1999). The increase in higher frequency activity within this same region after the end of Track 3 is consistent with studies that have implicated the anterior cingulate in modulating attention (Bush *et al.*, 1999; Carter *et al.*, 1997). Specifically, activation of this region may have been mediated by the subject's attention to scenic images induced by the soundtrack.

The involvement of the anterior cingulate both compliments and extends the subjective, historical, and phenomenological relationships between specific patterns of sounds, such as music, and the report of enhanced emotional affiliation or bonding with those patterns and the people or context in which they occur. Recent fMRI results indicate that the anterior cingulate is specifically activated in tasks where in-group vs. out-group membership (belonging or not belonging to a group) is manipulated (Krill and Platek, 2009). The anterior cingulate is associated with the autonomic components associated with behaviors and experiences labeled as "love" as well as behaviors implicated in decision-making, conflict detection, reward tracking, and the emotional control involving social sensitivity and moral reasoning (Moll *et al.*, 2003; Critchley *et al.*, 2003; Lorberbaum *et al.*, 2002). These experiences, particularly "love" or intense affiliation, share many of the characteristics with addiction to opioid compounds generated by the body and when consumed from exogenous sources. Removal of the stimuli for either of these states, either the opiate or the person, results in very similar withdrawal behaviors including sadness, changes in appetite, and the

conviction to engage in behaviors that will minimize this aversive state such as rekindled proximity to the pleasant state.

Conclusion

The results of this study suggest that sounds appropriately recorded from 'sacred' places may induce electroencephalographic profiles that are consistent with altered or mystical states. The subjective scenic visual imagery accompanying the presentation of a soundscape was related to imaginal spaces and was associated with increased gamma within the frontal and cingulate regions. These regions are areas associated with attention and meditation, as well as enhanced coherence between the left temporal and right frontal regions, which have been described a major correlate of out-of-body experiences. In non-laboratory settings, these experiences might include "displacement" to mystical places where culture-specific deities or ancestors might be encountered and "information" shared. The involvement of the cingulate region would increase the emotional significance, sense of "bonding" with the attributed origin of the experiences as well as enhanced suggestibility to subsequent verbal instructions by proximal persons in the group or post-hoc explanations by the experient.

Acknowledgments

The authors would like to acknowledge the support of the Province of Alberta through a grant from the Alberta Foundation for the Arts. The authors would also like to thank Dr. M.A. Persinger for his technical comments and assistance.

References

- Besant A and Charles W. Thought-Forms. London, Theosophical Publishing House. 1901.
- Buckner RL and Petersen SE. What does neuroimaging tell us about the role of prefrontal cortex in memory retrieval? *Seminars in the Neurosciences* 1996; 8: 47-55.
- Bush G, Frazier JA, Rauch SL, Seldman LJ, Whalen PK, Jenike MA et al. Anterior cingulate cortex dysfunction in attention-deficit/hyperactivity disorder revealed by fMRI and the counting stroop. *Biological Psychiatry* 1999; 45(12): 1542-1552.
- Buzsaki G. Theta oscillations in the hippocampus. *Neuron* 2002; 33: 325-340.
- Carter CS, Mintun M, Nichols T, Cohen JD. Anterior Cingulate Gyrus Dysfunction and Selective Attention Deficits in Schizophrenia : [¹⁵O]H₂O OET Study During Single-Trial Stroop Task Performance. *The American Journal of Psychiatry* 1997; 154, 1670-1675.
- Critchley HD, Mathias CJ, Josephs O, O'Doherty J, Zanini S, Dewar B-K, Cipolotti L, Shallice T, Dolan RJ. Human cingulate cortex and autonomic control: converging neuroimaging and clinical evidence. *Brain* 2003; 126: 2139-2152.
- Fletcher PC and Henson RNA. Frontal lobes and human memory: insights from functional neuroimaging. *Brain* 2001; 124: 849-881.
- Henkin RI and Levy LM. Lateralization of Brain Activation to Imagination and Smell of Odors Using Functional Magnetic Resonance Imaging (fMRI): Left Hemispheric Localization of Pleasant and Right Hemispheric Localization of Unpleasant Odors. *Journal of Computer Assisted Tomography* 2001; 25(4): 493-514.
- Holtz EM, Glennon M, Prendergast K, Sauseng P. Theta-gamma phase synchronization during memory matching in visual working memory. *NeuroImage* 2010; 52: 326-335.
- Hoppál M. Music of Shamanic Healing. In Gerhard Kilger. *Macht Musik. Musik als Glück und Nutzen für das Leben*. Köln: Wienand Verlag. 2006.
- Krill A and Platek SM. In-group and out-group membership mediates anterior cingulate activation to social exclusion. *Frontiers in Evolutionary Neuroscience* 2009, doi: 10.3889/neuro.18.001.2009
- Lavallee CF, Koren, SA and Persinger MA. A quantitative electroencephalographic study of meditation and binaural beats. *The Journal of Alternative and Complementary Medicine* 2010; In Press.
- Lou HC, Kjaer TW, Friberg G, Wildschiodtz SH and Nowak A. A ¹⁵O-H₂O PET study of meditation and the resting state of normal consciousness. *Human Brain Mapping* 1999; 7, 98-105.
- Lindenberger U, Li S, Gruber W, Muller V. Brains swinging in concert: cortical phase synchronization while playing guitar. *BMC Neuroscience* 2009; 10(22): 1-12.
- Loberbaum JP, Newman JD, Horowitz AR, Dubno JR, Lydiard RB, Hamner MB, Bohning DE, George MS. A potential role of the thalamocingulate circuitry in human maternal behavior. *Biological Psychiatry* 2002; 51: 431-445.
- Lutz A, Greischar LL, Rawlings NB, Ricard M, Davidson RJ. Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *PNAS* 2004; 101(46): 16369-16373.
- Metzner R. Transformation Processes in Shamanism, Alchemy and Yoga. In Shirley Nicholson. *Shamanism*. Wheaton, Illinois: Quest Books. 1987. p.340.
- Moli J, de Oliveira-Souza R, Eslinger PJ. Morals and the human brain: a working model. *NeuroReport* 2003; 14:299-305.
- Neher A. Auditory Driving Observed with Scalp Electrodes in Normal Subjects. *Electroencephalography and Clinical Neurophysiology* 1961;13: 449-451.
- Parsons LM. Exploring the functional neuroanatomy of music performance, perception and comprehension. *Annals of the New York Academy of Sciences* 2001, 930: 211-231.
- Persinger MA. Striking EEG profiles from single episodes of glossolalia and transcendental meditation. *Perceptual and Motor Skills* 1984; 58: 127-133.
- Persinger MA, Roll WG, Tiller SG, Koren SA and Cook CM. Remote viewing with the artist Ingo Swann: Neuropsychological profile, electroencephalographic correlates, magnetic resonance imaging (MRI), and possible mechanisms. *Perceptual and Motor Skills* 2002; 94(3): 927-949.
- Persinger MA, Tsang EW, Booth JN and Koren SA. Enhanced Power within a Predicted Narrow Band of Theta Activity During Stimulation of Another By Circumcerebral Weak Magnetic Fields After Weekly Spatial Proximity: Evidence for Macroscopic Entanglement. *Neuroquantology* 2008 ; 6(1): 7-21.
- Persinger MA, Saroka K, Koren SA and St-Pierre LS. The Electromagnetic Induction of Mystical and Altered States within the Laboratory. *Journal of Consciousness Exploration and Research* 2010; 1(7):808-830.
- Persinger MA, Saroka K, Mulligan BP, Murphy TR. Experimental Elicitation of an Out of Body Experience and Concomitant Cross-Hemispheric Electroencephalographic Coherence. *NeuroQuantology* 2010;8(4): 466-477 .
- Quinn I. Minimal Challenges: Process Music and the Uses of Formalist Analysis. *Contemporary Music Review* 2006; 25(3): 283-294.
- Schmidt LA, Trainor LJ. Frontal brain electrical activity (EEG) distinguishes valence and intensity of music emotions. *Cognition and Emotion* 2001; 15(4): 487-500.
- Schneider A. Spontaneous confabulation and the adaptation of thought to ongoing reality. *Nature Reviews* 2003; 4: 662-671.
- Setpram. Sri Aurobindo or the Adventure of Consciousness. New Delhi: Mysore, & The Mother's Institute of Research. 1964.
- Tomatis A. *The Conscious Ear: My Life of Transformation through Listening*. Barrytown, NY: Station Hill Press. 1991.
- Turhan C. Hemispheric asymmetry for emotional stimuli detected with fMRI. *Neuroreport* 1999; 9(14), 3233-3239.