



**COGNITIVE SCIENCE & NEUROSCIENCE | RESEARCH ARTICLE**

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# Brain changes during a shamanic trance: Altered modes of consciousness, hemispheric laterality, and systemic psychobiology

Pierre Flor-Henry<sup>1</sup>, Yakov Shapiro<sup>1\*</sup> and Corine Sombrun<sup>2</sup>

**Abstract:** There have been a number of electrophysiological and neuroimaging studies in “altered” states of consciousness including dissociative conditions, hypnosis, and meditation; however, the nature and clinical significance of trance states remain elusive. Alterations of consciousness that accompany trance can shed light on the brain networks contributing to the experience of autobiographical self; the subjective demarcation of “self” from others and reality at large; and normative vs. pathological domains of self-experience. Shamanic trance is a volitional, self-induced state of consciousness that historically served the purposes of social cohesion and healing interventions in diverse tribal settings. We present the first neurophysiological study of a normal subject, who has received extensive training in the Mongolian shamanic tradition and is capable of self-inducing a trance state without external sensory stimulation. Quantitative EEG mapping and LORETA (low resolution electromagnetic tomography) source imaging indicate that shamanic state of consciousness (SSC) involves a shift from the normally dominant left



Pierre Flor-Henry

### ABOUT THE AUTHORS

Prof Pierre Flor-Henry is an internationally recognized expert in the fields of hemispheric laterality and spectral EEG imaging, with over 120 publications in the field. The annual Flor-Henry Lectures international conference has been established in his honor in Edmonton, Canada.

Prof Yakov Shapiro specializes in the field of psychotherapy/psychopharmacology integration and teaches courses on evolutionary psychiatry, neuroscience of psychotherapy, and psychobiology of self-experience at the University of Alberta, Canada.

Corine Sombrun was the first Westerner to achieve the status of ugdan (female shaman) in the Mongolian shamanic tradition, and has published extensive phenomenological accounts of the field. She is involved in ongoing research in shamanic trance states.

### PUBLIC INTEREST STATEMENT

Shamanic states of consciousness (SSC) go back to the dawn of the middle Paleolithic “cognitive revolution” some 70,000 years ago. They represent humanity’s most ancient spiritual tradition that lies at the core of religion and culture as we know them today. A diverse set of findings in neurophysiology and cultural anthropology research suggest that altered modes of consciousness can shed light on the brain mechanisms contributing to the experience of unitary “self” and normative vs. pathological domains of self-experience.

We present the first neurophysiological study of a normal subject and our co-author, who had received extensive training in the Mongolian shamanic tradition and is capable of inducing a shamanic trance state at will. We integrate original research with extensive literature review and suggest a unified psychobiological model for “altered” modes of consciousness. This model incorporates objective, subjective, and intersubjective science within a broad evolutionary framework. It provides a non-reductionist account of psychological, biological, and social determinants of self-experience that helps bridge Western and traditional healing techniques.

analytical to the right experiential mode of self-experience, and from the normally dominant anterior prefrontal to the posterior somatosensory mode. These findings have implications for the psychobiology of the normative conscious mode of awareness and neurophysiological processes contributing to dissociative, psychotic, and transpersonal domains of self-experience. They may be used as a foundation to bridge Western and traditional healing techniques.

**Subjects:** Social & Cultural Anthropology; Evolutionary Psychology; Integrative Psychotherapy; Behavioral Neuroscience; Neuropsychiatry

**Keywords:** altered states; consciousness; EEG; first-person neuroscience; psychotherapy; psychobiology; shamanic; self

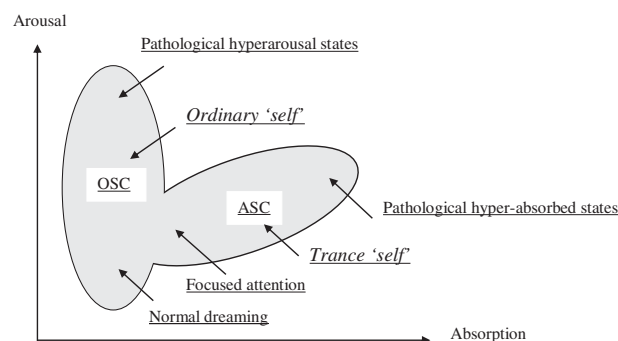
### 1. Introduction

Our normal waking consciousness, rational consciousness as we call it, is but one special type of consciousness, whilst all about it, parted from it by the flimsiest of screens, there lie potential forms of consciousness entirely different. ... No account of the universe in its totality can be final which leaves these other forms of consciousness quite discarded. How to regard them is the question, for they are so discontinuous with ordinary consciousness. (William James, "Varieties of religious experience", 1902)

The category of *altered states of consciousness* (ASCs), to which trance experiences belong, forms the second domain of conscious experience in addition to ordinary states of consciousness (OSCs). Trance is defined as a "temporary marked alteration in the state of consciousness or loss of customary sense of personal identity" (International Classification of Disorders, 1992), which can be either normative or pathological. The normative end of the ASC spectrum involves alterations in the autobiographical sense of self, from expanded states of absorption (such as creative flow and meditative practices) to hypnotic trance; culture- and religion-specific practices including shamanic states of consciousness (SSC); and various modes of extra-sensory perception. Drug-induced psychedelic trances, synesthesias, savant capacities, and near-death experiences lie in the middle of the scale, while pathological ASC conditions include dissociative trance disorder, lycanthropy and related cultural practices, dissociative conditions such as Dissociative Identity Disorder (DID) and psychogenic fugues, and neuropsychiatric syndromes, such as temporal lobe epilepsy, schizophrenia, and affective psychoses where the sense of self may be radically altered or lost. One important corollary is that trance and altered states are not necessarily associated with psychopathology and may in fact be therapeutic (Money, 2000).

Both ordinary and altered domains of conscious experience can be conceptualized as a function of arousal vs. absorption extending from normality to psychopathology (Figure 1). The *arousal axis* extends from sleep and dreaming to normal wakefulness to heightened excitement and pathological self states involved in catatonia or manic psychosis. The orthogonal *absorption axis* incorporates

**Figure 1. Ordinary (OSC) vs. altered (ASC) states of consciousness as a function of arousal/absorption.**



normative self states of relaxed wakefulness progressing to focused attention, and pathological states of derealization/depersonalization, autoscopy, dissociative fugue, and DID. While the normal autobiographical self is identified with the dominant linguistic hemisphere (left in dextral population), there is evidence that some of the “altered states” phenomena may result from intrusions of non-dominant right hemispheric content into waking awareness (Persinger, 1993).

Contrary to the prevalent Western belief, ASCs are extremely common: anthropological studies show that of the 488 societies studied worldwide, over 90% were found to have an institutionalized form of ASCs, and 57% of these were possession trances (Oohashi et al., 2002). A recent cross-sectional study of normal British population (Pechey & Halligan, 2012) estimated the prevalence of anomalous experiences at 48%. Culture-bound religious and/or spiritual beliefs are a major factor determining their specific context. Within a particular social group, altered states can be experienced as either pathological (such as possession trance) or beneficial (such as meditative and shamanic practices). In fact, from the perspective of some meditative practices such as Zen Buddhism, it is the normative “dual” state of consciousness that fragments our perception into inner and outer reality and contributes to suffering and psychopathology. The expressed goal of many meditative practices therefore lies in achieving a non-dual state of unitary awareness (Berman & Stevens, 2015). Conversely, the Western rational tradition tends to pathologize ASC phenomena based on reductionist and behaviorist medical models, although there has been an increasing number of anthropological and neurobiological studies in recent years attempting to clarify their normative phenomenology and neurobiological mechanisms (Jilek, 2005; Vaitl et al., 2005).

There is a common mode of consciousness that may serve to bridge ordinary and altered self-experience. It is related to various types of focused attention, where conscious awareness is narrowed on either inner or outer content to the exclusion of wider self/world awareness. These states range from the everyday experience of focusing on a task at hand; to absent-mindedness (internal focus to the exclusion of environmental cues); to peak experiences and “flow states” (Csikszentmihalyi, 1996) linked to creativity or musical performance; to hyper-focused attention practices such as meditation and hypnotic trance. Narrowed attention states can be conceptualized as a form of “normative dissociation” induced by either external triggers or internal-imaginative processes (Seligman & Kirmayer, 2008).

Psychoevolutionary understanding of normative dissociation states suggests an adaptive function akin to the “freezing” response in dealing with inescapable threat, where neither fight nor flight alternatives are available. The resultant uncoupling from self/world awareness results from a deficit in normal integration of perceptions, feelings, thoughts, and experiences into verbal reflective consciousness, with consequent alterations in the coherent autobiographical narrative self. Dissociative states dampen autonomic and emotional reactivity, resulting in a combination of focused hypervigilance characterized by “simultaneous multisensory scanning of relevant information from the environment” while detaching from one’s self and the world at large, which may manifest as depersonalization/derealization (Seligman & Kirmayer, 2008). Experiences of early physical or psychological trauma may facilitate the development of dissociative defenses leading to trauma spectrum disorders, such as predisposition to chronic/complex post-traumatic stress disorder (PTSD, Herman, 1992), borderline personality states, and dissociative spectrum syndromes such as psychogenic amnesias and DID. It is important to note that such dissociative processes are characterized by *both* deficits in normative integration of self/world experiences *and* rich internally driven imagery, which can be experienced in multiple sensory modalities. In discussing the traumatic etiology of pathological trance states, Castillo (2003) notes:

Some people can withdraw from reality by means of profound spontaneous trances, usually secondary to stress or psychological trauma, and create a fantasy experience by narrowly focusing their attention on imaginary structures or remembered traumatic events while blocking out external reality. (pp. 13–14)

The International Classification of Disorders (ICD) first listed the proposed criteria for Dissociative Conversion Disorder in 1989, and officially included it in ICD-10 (1992). The Diagnostic and Statistical Manual of Psychiatric Disorders (DSM) listed a proposed diagnosis of Dissociative Trance Disorder in DSM-IV (1994). Both classifications differentiated between trance and possession (defined as “single or episodic alteration in the state of consciousness characterized by the replacement of customary sense of personal identity by a new identity... attributed to the influence of a spirit, power, deity, or other person”). To be considered pathological, trance and possession states must occur involuntarily, cause significant distress or impairment to the individual, and not be a part of a culturally or religiously accepted practice. A comprehensive literature review by During, Elahi, Taieb, Moro, and Baubet (2011) for the period between 1988 and 2010 identified 402 case reports satisfying the criteria for DTD, with a 2:1 predominance of possession subtype (69%), a mean age of 25.2 years at the time of the first episode, and equal sex ratio.

A critical distinction between normative vs. pathological ASCs is the capacity for voluntary control in the service of a specific goal (Etevenon, 2010). This is one of the distinguishing features of meditative, shamanic, and other non-pathological trance states. Specifically, the historic ability of shamanic practitioners to enter trance as a way of bridging systemic social interactions with their increasingly complex inner representations distinguishes them from dissociative or psychotic conditions. In spite of an earlier tendency to label shamanic experiences as primitive and pathological, later studies link them to cohesion and evolution of sociability in tribal groups (Krippner, 2002; Stephen & Suryani, 2000). The resulting integration of cognitive and intuitive modes of experience may have promoted the evolution of culture and religion as we know them today (Winkelman, 2010).

The purpose of this study is to:

- (1) Clarify to what extent shamanic trance states may represent psychopathology vs. an anomalous but non-pathological mode of brain functioning. We therefore compared detailed spectral EEG parameters of our experimental subject and co-author in both normal and trance states with pre-recorded banks of normal, schizophrenic, manic, and depressed female dextral subjects.
- (2) Demonstrate specific alterations in brain function that accompany shamanic trance state using the experimental subject as her own control. We hypothesized that the relatively non-verbal and highly sensory experiences of the trance would be accompanied by a shift from the normally dominant left hemispheric verbal mode of conscious awareness to a relative predominance of right hemispheric activation previously demonstrated to accompany altered states (Krippner & Combs, 2002; Persinger, 1993).

## 2. Phenomenology of the shamanic state of consciousness

Shamanic States of Consciousness are a distinct sub-category of ASCs characterized by lucid but narrowed awareness of physical surroundings, expanded inner imagery, modified somatosensory processing, altered sense of self, and an experience of spiritual travel to obtain information necessary for solving a particular individual or social problem. It is best understood not as a religion but as a set of ethnically defined healer/medium practices systematically utilizing ASCs for the purpose of healing and tribal group cohesion, such as persistent health problems, within-group conflicts, and threats to the group as a whole (Wright, 1989). Shamanic states are therefore purposeful and volitional unlike psychotic or dissociative conditions. A recent review by Frecska, Hoppál, and Luna (2016) defines SSCs as “a form of focused and expanded consciousness, closer to meditative states, in which the participant intentionally shifts his or her awareness from ordinary perception toward a different ‘input’, which seems to originate from ‘within’” (p. 157). Winkelman (2010) similarly conceptualizes SSCs as a hyper-focused “integrative state” that transcends the limits of the ordinary “rational self” and helps identify the sources of discord within the individual, their tribal group, and wider environment, not unlike the techniques of dream analysis and free association in the Western psychoanalytic and Jungian traditions (Knox, 2009).

Anthropological evidence demonstrates that shamanic traditions are a universal form of cultural practices around the globe and may represent humanity's earliest spiritual practice, predating all known religions (VanPool, 2009). Based on commonalities to shamanic practices of Australian aborigines, who became culturally isolated between 50,000 and 65,000 years ago, shamanism can be traced to the middle Paleolithic period at the onset of the Cognitive Revolution around 70,000 BP (Peters, 1989). There are several broad domains of shamanic practices including African; Siberian/Mongolian; native South and North American (seen as descendants of the Siberian tradition); and Asian-Pacific, including Australian aborigines. The origin of the "shaman" term stems from the Evenki people in the Tungus region of southwestern Siberia ("šamán" meaning "one who knows"). The term "shamanistic" (as opposed to "shamanic") practice is reserved for utilizing shamanic trance techniques outside of their original sociocultural context, such as in Western industrial societies.

While shamanic practices are diverse and may include the use of psychoactive drugs (such as ayahuasca and peyote), drumming, dancing, or environmental triggers (such as Native sweat lodge ceremonies), one common pathway involves the phenomenon of a "shamanic journey"—the intentional induction of an altered state of consciousness to facilitate individual growth or adaptive functioning in a tribal group. Nishimura (1987) described three types of shamanic journeys, although they are not always distinct:

- (1) *Ecstatic trance*, in which the shaman's spirit purportedly leaves the body and communicates with animal or other spirits in their domains,
- (2) *Possession trance*, in which animal or other spirits enter the shaman's body, sometimes to the exclusion of his or her own self, and
- (3) *Dreamlike trance*, in which the shaman remains in possession of the self and meets animal or other spirits in a shared domain.

The phenomenon of a "shamanic call", or initiation into the shaman's role, is worth mentioning here. Several common pathways have been described in the literature including a violent personal crisis, intense anxiety, and social withdrawal accompanied by "dreams, visions or inner voices" (Wright, 1989). While in the Western cultures these symptoms may accompany the prodromal phase of a psychotic illness, a tribal group member identified to possess "shamanic gifts" would then proceed with shamanic initiation and training. There is evidence that shamanic trance capacity is not culture-bound but may represent "an inherent psychobiological predisposition ... perhaps universal in the species" (Noll, 1983). One of the authors (C.S) has been researching digital musical loops derived from the shamanic drum beat, and achieved over 80% trance induction response in normal college population (personal communication). In fact, the ability to convert sensorimotor imagery into symbolic stories inherent in shamanic practices may have been pivotal to the gradual emergence of abstract thinking and the evolutionary success of *Homo sapiens sapiens* (Krippner, 2000).

In their contextual variable analysis, Houran, Lange, and Crist-Houran (1997) describe eight experiential categories common to altered and SSC states, the first four corresponding to sensory modalities (*visual, auditory, olfactory, and tactile*), with additional categories of *sensed presence, intense emotionality, unexplained object movement, and erratic functioning of complex machinery* (such as unaccountable malfunction of electrical or mechanical equipment in the vicinity). The authors cite Walsh (1989) stating that "the experiential content of the shamanic journey is complex and coherent...highly structured, meaningful, consistent with the shaman's learned cosmology and the purpose of the specific session, and [apparently] under partial voluntary control" (p. 60). They conclude that shamanic experiences are not limited to psychopathology or a biologically determined set of archetypal perceptions but rather represent a constructivist synthesis of the individual's beliefs and specific cultural factors within the tribal group.

### 3. Psychophysiology of altered and shamanic states of consciousness

Similar neurophysiological markers have been documented in diverse trance states including yoga and shamanic practices; Zen Buddhist and transcendental meditation; psychedelic experiences associated with hallucinogenic drugs; mediumship/psychography; hypnosis; and shamanic states. These include:

- (1) Generalized shift toward right hemisphere dominance (Krippner & Combs, 2002). This may represent a core feature of ASCs resulting from right hemispheric activation and homologous trans-callosal inhibition of contralateral left hemispheric functions responsible for ordinary, ego-bound states of consciousness.
- (2) Greater proportion and amplitude of alpha band (8–13 Hz) activity with anterior–posterior synchronization (Banquet, 1973). These oscillations are thought to originate from thalamo-cortical feedback loops responsible for somatosensory binding (Cahn & Polich, 2006). Subjective correlates include relaxed wakefulness, creativity, and free association.
- (3) Increased theta power and short, synchronous bursts of high-voltage theta waves (4–7 Hz), which are distinct from those observed in drowsiness/sleep states and correlate with subjective reports of blissful awareness accompanied by rich visual imagery and dissolution of ego boundaries (Wright, 1989). Theta frequencies are thought to represent coherent limbic activity in the septal areas, amygdala, and hippocampal projections to association cortices responsible for emotional, cognitive, and memory information processing (Kirenskaya, Novototsky-Vlasov, & Zvonikov, 2011), and may represent inhibitory influence on the prefrontal association cortices.
- (4) Increased gamma power thought to represent diffuse cortical activation and integrative conscious information processing (Lehmann et al., 2001).
- (5) Synchronization of EEG activity between left and right frontal lobes, which may be accompanied by progressive frontal hypoactivation in deeper forms of trance (Dietrich, 2003).
- (6) Generalized shift toward parasympathetic dominance and release of endogenous opioids, which may be responsible for the subjective reports of ecstasy and decreased pain perception (Krippner & Combs, 2002).

There is extensive data involving lateralized effects in altered self experience. Right hemisphere activation has been linked to a diverse range phenomena including autoscopy, depersonalization/derealization, out-of-body experiences, and voluntarily altered states such as self-dissolution meditation (Lehmann et al., 2001). Persinger (1993) used the construct of *vectorial cerebral hemisphericity* to provide neurophysiological evidence for right hemispheric intrusion phenomena, which are perceived as subjectively ego-alien, coming as it were from “outside” of the conventional left hemispheric, linguistically based mode of self-awareness. He states: “The right hemispheric intrusions are experienced as sensed presences that are described as ‘impressions’, ‘entities’, ‘ghosts’, ‘old hags’, cosmic consciousness and spiritual beings; the experiences are maximally affective and minimally linguistic and are judged more frequently as unpleasant ...” (p. 916). In subsequent works, Cook and Persinger (1997) pioneered the transcranial magnetic stimulation (rTMS) paradigm and were successful in replicating such presence phenomena in normal college population with a complex magnetic field simulating amygdaloid neuronal firing patterns. Interestingly, visual correlations of the “presences” were most frequently encountered in the left visual field, supporting their right hemispheric origin.

Sabourin et al.’s (1990) spectral EEG analysis of hypnotic trance showed that highly hypnotizable subjects generated more theta power at all occipital, central, and frontal locations, more pronounced in the anterior regions. These frequencies are inhibitory in nature and correlate with enhanced attention and imagery, the highly hypnotizable group also reporting higher absorptive attentional skills. The authors suggest that increased fronto-central theta power may represent *class II inhibition*, with “selective deactivation of particular responses so that a continuing excitatory state becomes directed or patterned” (by contrast, class I or global inhibition relates to general

inactivity and drowsiness). According to Michel, Lehmann, Henggeler, and Brandeis (1992), the associated state of hippocampal-septal hypersynchrony linked to hippocampal sources correlates with a “transpersonal mode” of experience accompanied by expanded consciousness and creative thought.

A recent study by Kirenskaya et al. (2011) showed sharply elevated coherence between distributed brain regions in alpha and theta bands among highly hypnotizable subjects. In addition, the authors demonstrated increased posterior-frontal coherence in beta and gamma (38–42 Hz) bands, suggesting that highly hypnotizable subjects preferentially engage in hypnotic trance imagery rather than verbal processing. These findings are consistent with the observations of increased global gamma coherence in the naturalistic conditions of ayahuasca-induced trance (Stuckey, Lawson, & Luna, 2005). Since beta and gamma activity is thought to be predominantly cortically generated, these findings suggest that distributed cortical hyper-coherence correlates with the subjective reports of intense synesthetic experiences and dissolution of ego boundaries. More specifically, Lehmann et al. (2001) have shown increased right posterior gamma sources in subjects practicing visual meditations vs. increased right anterior gamma sources in meditative self-dissolution, and left central gamma sources in verbal-based mantra meditations.

Flor-Henry, Lind, and Kole (2013) demonstrated relative right brain activation and left/frontal hypofunction in males with cannabis-induced psychosis, with increased beta and gamma sources in the left temporo-parietal region. In an earlier discussion of dissociative and stable hysteria syndromes, Flor-Henry (1983) concluded that in view of the evidence already available at that time, the fundamental problem was a defect in sensorimotor integration evidenced by bilateral frontal dysfunction ( $R > L$ ) that comes as a consequence of altered left-dominant systems producing a secondary disorganization of the contralateral hemisphere.

Neuroimaging studies of psychedelic-induced altered states (Carhart-Harris et al., 2012) show evidence of default mode network (DMN) inhibition in transition from normal waking consciousness. Surprisingly, the profound consciousness alterations under the influence of psilocybin are only associated with *decreases* in the regional blood flow specific to the hub regions of sensory and self-referential information processing in the thalamus, anterior and posterior cingulate, and medial prefrontal cortex. The authors suggest that psychedelic effects are primarily due to the release from DMN inhibition leading to “unconstrained cognition”. A recent fMRI study by Lutz, Brühl, Scheerer, Jäncke, and Herwig (2016) in long-term meditators similarly showed decreased activation of the cortical midline structures involved in the DMN during subjective experiences of mindful awareness, coupled with increased activation in somatosensory regions.

The first specific fMRI study of shamanic trance by Michael Hove’s team at Harvard (2015) showed higher neural network connectivity in posterior cingulate (PCC), dorsal anterior cingulate cortex, and left insula. These findings point to co-activation of the default network for internally oriented cognitive states, and modulatory control networks which help focus attention on the relevant internal stimuli. There was an associated finding of perceptual (auditory) decoupling, which would serve to close down external sensory channels. Parallel findings of PCC activation were noted in experienced mindfulness meditators and normal dreaming (Ives-Deliperi, Solms, & Meintjes, 2011), although decreased control network activity in REM states results in involuntary dreaming experience rather than voluntary, lucid visions of a shamanic trance. While the rate of drum beat of four beats per second (4 Hz) to induce the trance state in the study is consistent with the previous suggestions of an auditory driver for increased theta power, the authors rather suggest the mechanism of gating and suppression of the highly predictable sensory input leading to decreased cortical activity. By contrast, they observe that “an unpredicted rhythmic shift is commonly used to end the shamanic journey and helps disengage from the trance and reengage with the sensory world” (p. 6). They conclude that a shamanic journey should be seen as “a goal-directed exploratory state, wherein nascent and previously disparate mental contents can be stimulated, evaluated, and integrated,”



and suggest that “shamanic trance involves a reconfiguration of connectivity between brain regions that is consistent across individuals and thus cannot be dismissed as an empty ritual” (p. 7).

In this paper, we present the first detailed spectral EEG study of a normal subject who was trained to induce a shamanic trance and is presently able to enter it without the sound of the drum. She was the first Westerner to achieve the designation of *udgan* (a Mongolian female shaman).

#### 4. Case history

The subject and one of the authors (C.S) is an only child born in Draguignan, in the south of France. She spent her early years in Ouagadougou (Burkina Faso) in Africa. She underwent a near-death experience in Africa at the age of 11 months due to an allergic reaction to smallpox vaccine. After her parents’ divorce at the age of eight, she was raised by her mother in France; her father stayed in Africa and she visited him for summer holidays. She studied musicology, piano, and composition, and after winning national and international competitions in 1986, she received a scholarship from the Franco-Quebecois Youth Office to study with multimedia performers and composers in Montreal.

Following a traumatic episode in 1999 when her partner of 10 years died, she moved to London, England where she pursued a career as a pianist/composer and worked as a reporter for BBC World Service. In 2001, during a report on Mongolia (“Mongolian mysteries” aired on BBC World Service in 2002), the sound of a shamanic drum induced a violent crisis when she could no longer control her movements. A Dakhad shaman (one of the 31 ethnic Mongolian groups) recognized her as having unique shamanic gifts and invited her to apprentice for Shaman training (Sombrun, 2004). She traveled to Mongolia near the Siberian frontier for the following eight years, being taught shamanic practices by an *udgan* Enkhetuya belonging to the Tsaatans ethnic group. In 2009, C.S became the first Westerner to achieve the status of *udgan* herself.

In 2005, C.S traveled to New Mexico to meet with Harlyn Geronimo, a medicine man and great-grandson of the famous Apache warrior. According to the Apache legend, this Indian tribe had originated in Mongolia (this is consistent with paleoanthropological and genetic data on the Bering land bridge migration route from Eastern Siberia to Alaska between 12,000 and 14,000 years ago—Wang et al., 2007). In 2008, C.S continued with her research on the migration of Mongolian tribes and went to Alaska where she met Athabascan Indians, presumed ancestors of the Apaches and descendants of the Mongols.

C.S. first experienced a spontaneous trance at the age of six, when she and her parents were attending a tribal funeral ceremony in Burkina Faso. She remembers being completely absorbed by the music, her mother later telling her that she began to shake, which spread to all of her body. Following her spontaneous trance experience in Mongolia, she came to Prof. P. Flor-Henry’s Clinical Diagnostic and Research Centre at Alberta Hospital Edmonton in Canada in an attempt to elucidate the physiological mechanisms underlying her ability to induce a shamanic trance.

C.S continues to compose music, give lectures, and research the mechanisms of SSCs. She is involved in ongoing research in shamanic trance states with Pr Edward Frenkel (University of California, Berkeley, USA), Pr Francis Taulelle (KU Leuven, Belgium), Pr Patrick Lemoine (Lyon University, France and Peking University, China) and Pr Marc Henry (Strasbourg University, France). She designed a digital sound loop with Elie D. Lequemener modeled from original musical pieces played to induce trance by shamans. During a course on trance and creativity in December 2015, it was played to students of Beaux-Arts in Nantes, with 16 out of 20 students undergoing a trance induction and subsequently returning to their normal state. Follow-up study is presently in progress. These findings demonstrate that trance states may be much more common than what is generally accepted, representing an underused potentiality rather than an exceptional gift or psychopathology.

## 5. Methodology

### 5.1. Subjects

Our experimental subject's spectral EEG parameters were compared to the bank of previously investigated control groups of normal, schizophrenic, manic, and depressed dextral female subjects (the numbers vary slightly due to the removal of cases with EEG artifacts in various frequencies). When tested at the age of 45, our subject was within the age range of manic (mean age  $44.87 \pm 12.32$  years) and depressed ( $37.39 \pm 10.94$ ) age groups, but slightly older than the schizophrenic (mean age  $35.33 \pm 8.82$  years) and normal control samples (mean age of  $25.57 \pm 8.37$  years). However, the normalization of the cross-spectral matrix from each subject by its trace (total EEG power in the band) was used to eliminate any dependence of EEG power on age. Specifically, Klimesch (1999) documented that with increasing age, absolute power in the alpha and theta oscillations decreases while upper alpha power increases, and overall alpha power increases from early childhood to adulthood and then progressively decreases with age. Consequently, the peak alpha frequency of the subject, controls, and comparison schizophrenic, manic, and depressed populations was analyzed.

Comparison subjects were all unmedicated at the time of their data recordings. All subjects were completely right handed as determined by the handedness questionnaires (see the experimental protocol in Koles, Lind, & Flor-Henry, 2004). The pretest interview was used to exclude illicit drug use, medication, alcohol abuse, migraine or other neurological disorders, comorbid psychiatric disorders, birth complications, and head trauma. In addition, the Quick Diagnostic Interview Schedule, the Basic Personality Inventory, and the Multidimensional Aptitude Battery, which provides verbal, performance, and full-scale IQ, were administered to all patients and controls.

EEGs were recorded from all subjects during a passive condition, eyes open (EO) or eyes closed (EC), and a spatial cognitive task, dot localization (DL). At least 3 min of recording was obtained from each subject. During the passive condition, the subjects were told to relax, think of nothing in particular, and fix their gaze on a point across the room. The DL task contained 25 items, each consisting of two vertically arranged open rectangles, the top rectangle containing a pair of dots and the bottom rectangle, slightly offset to either the right or the left, containing an array of numbers. The offset of the bottom rectangle differed randomly among items such that half of the items were offset to either the right or the left side. Subjects were asked to indicate which two numbers in the lower rectangle corresponded to the location of the dots in the upper rectangle. Item difficulty is determined by the size of the number arrays, which varied in five levels, from 8 to 50 numbers. The experimental subject in this study was tested in both EO and EC conditions in her normal state, but only in the EC condition during the trance, which was necessary for trance induction.

The research protocol as outlined above was reviewed by the Ethics Review Committee of the Alberta Hospital Edmonton and found to be acceptable within the limitations of human experimentation. No third-party consents were necessary since our experimental subject is one of the co-authors for this project.

### 5.2. Recordings

EEG recordings were obtained using a 43-lead stretchable electrode cap containing tin electrodes. The 43 electrode sites represented standard electrode positions described in the American Electroencephalography Society Guidelines. The lead sites were AF<sub>3</sub>, AF<sub>4</sub>, FC<sub>5</sub>, FC<sub>6</sub>, FC<sub>1</sub>, FC<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub>, C<sub>1</sub>, C<sub>2</sub>, TP<sub>7</sub>, TP<sub>8</sub>, CP<sub>5</sub>, CP<sub>6</sub>, CP<sub>1</sub>, CP<sub>2</sub>, P<sub>3</sub>, P<sub>4</sub>, P<sub>1</sub>, P<sub>2</sub>, PO<sub>3</sub>, PO<sub>4</sub>, AF<sub>z</sub>, F<sub>z</sub>, FC<sub>z</sub>, C<sub>z</sub>, CP<sub>z</sub>, P<sub>z</sub>, PO<sub>z</sub>, FP<sub>1</sub>, FP<sub>2</sub>, F<sub>7</sub>, F<sub>8</sub>, F<sub>3</sub>, F<sub>4</sub>, FT<sub>7</sub>, FT<sub>8</sub>, T<sub>7</sub>, T<sub>8</sub>, P<sub>7</sub>, P<sub>8</sub>, O<sub>1</sub>, and O<sub>2</sub>. All leads were referenced to the left ear, then converted to average reference, and the impedance at each electrode was adjusted to be below 5 KΩ. Three additional channels were recorded: the electrocardiogram (EKG), a bipolar recording over the external canthus to the supra-orbit of the right eye to monitor vertical and horizontal eye movements (EOG), and one bipolar electromyogram (EMG) channel recorded from the temporomandibular region on the right and left sides. All channels were amplified using a Grass Neurodata system and digitized with a 12-bit RC Electronics analog to digital converter at a rate of 256 samples/s. The band pass was set at

3–80 Hz with the high pass controlled by a Grass Model 12A5 two-pole Butterworth filter with the 3 dB point set at 3 Hz. The anti-aliasing filter was an eight-pole Bessel function filter with the 3 dB point set at 80 Hz.

### 5.3. Spectral analysis

The digitized EEG records were visually edited offline in the attempt to select 20 non-overlapping, 1-s data segments corresponding to correct responses to the tasks. These were selected randomly from all of the one-second segments available from the subject. Segments that contained voltage spikes, large eye movements, or muscle activity were not selected for analysis. Only those patients and subjects who were able to contribute the 20 segments were admitted into the study.

The Fast Fourier Transform (FFT) was applied to each row of the data matrix formed by the 46 EEG, EKG, EMG, and EOG channels (as rows) and 256 time samples (as columns) collected during each second. Prior to the application of the FFT, each row of the data matrix was preprocessed by applying a 50% Hamming taper. With 256 samples in each one-second segment, the frequency resolution of the FFT along the columns of each transformed data matrix,  $V(f)$  was 1 Hz spanning the range of frequencies from 0 to 255 Hz. The selected columns from the transformed data matrices were characterized in terms of their cross-spectra. The cross-spectral matrices  $\Sigma(\alpha)$  and  $\Sigma(\beta)$  were formed as:

$\Sigma(\alpha) = V(\alpha) V^T(\alpha)$  and  $\Sigma(\beta) = V(\beta) V^T(\beta)$ , where  $V(\alpha)$  and  $V(\beta)$  are the alpha and beta columns from  $V(f)$  and  $T$  is the complex conjugate transpose. An average  $46 \times 46$  complex-valued cross-spectral matrix over the 20 segments available from each subject was then calculated for each frequency band and for each of the EO, EC, and DL conditions.

The correlated effects of the EKG, EOG, and EMG with the EEG were removed using the matched filtering technique, resulting in  $43 \times 43$  cross-spectral matrices for each subject/frequency band/condition. Each matrix was then normalized by dividing all of its elements by its trace (the sum of its diagonal elements). This procedure was implemented in order to remove the confounding effects of skull thickness on EEG power. For more technical details, please refer to Koles et al. (2004).

## 6. Results

### 6.1. Psychological testing

- Quick Diagnostic Interview Schedule:
  - No psychiatric disorders.
- Basic Personality Inventory:
  - Normal on all 12 personality dimensions.
- Eysenck Personality Inventory:
  - Neuroticism: 0 percentile
  - Extraversion: 40th percentile.

The experimental subject does not have any psychiatric history and has never required any psychotropic medication or psychotherapy.

### 6.2. Spectral EEG findings

#### 6.2.1. Centroid analysis

In her normal state, the subject is similar to 80 normal dextral female controls, in all frequency bands. This is true for both the EO and EC conditions, as well as when engaging in the non-dominant hemisphere DL task.

**Table 1. EEG frequency bands and sub-bands as defined in this study**

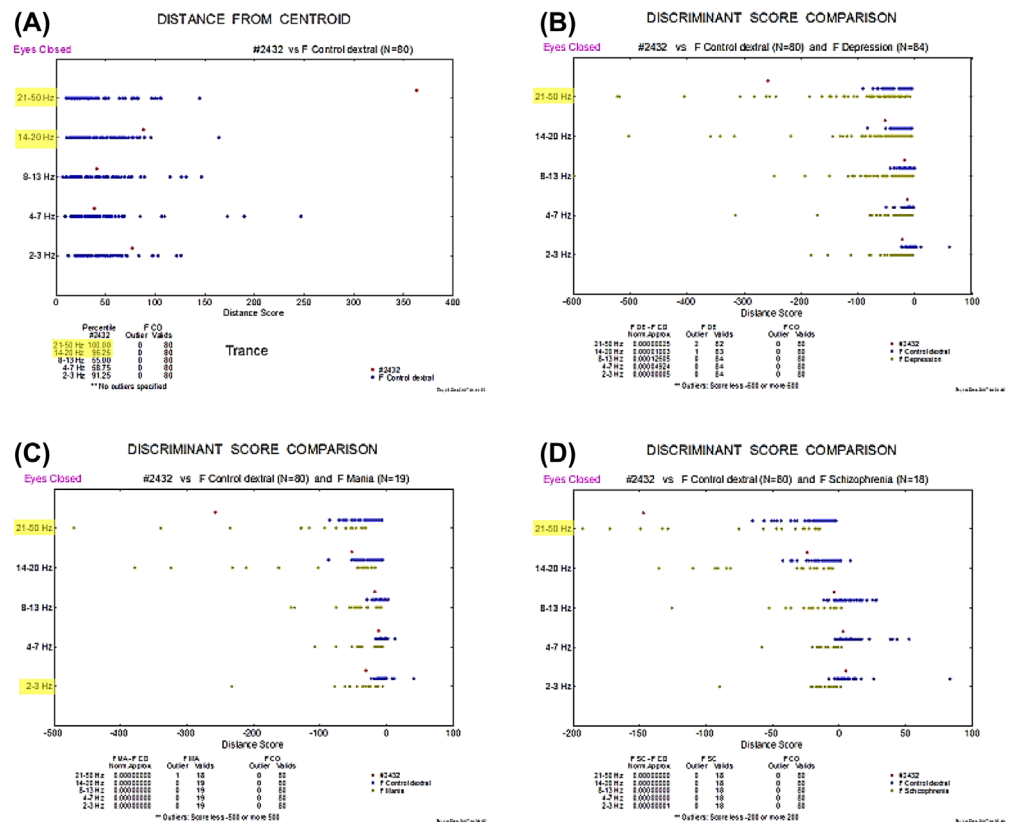
Delta	2–3 Hz
Theta	4–7 Hz
Alpha	8–13 Hz
Beta 1 (low beta)	14–20 Hz
Beta 2 (high beta)	21–50 Hz
Gamma	38–42 Hz
EMG	50–64 Hz

In the trance state, all measurements were taken in the EC condition, which was necessary for trance induction. The EEG frequency bands as used in this study are summarized in Table 1. Centroid analysis shows that the subject's trance EEG is similar to normal dextral female controls in alpha, theta, and delta bands but statistically different in low and high beta frequency bands (13–20 Hz and 21–50 Hz), with  $p < 0.04$  and  $p < 0.01$ , respectively (Figure 2(A)). Discriminant function comparison with unmedicated dextral females with schizophrenia ( $n = 18$ ); mania ( $n = 19$ ); depression ( $n = 84$ ); and control ( $n = 80$ ) reveals that in the trance state only, the subject's scores were fully outside the normal range and clustered within the depression and schizophrenia groups in the high beta band (Figure 2(B) and 2(D)); and within the mania group in the delta and high beta bands (Figure 2(C)).

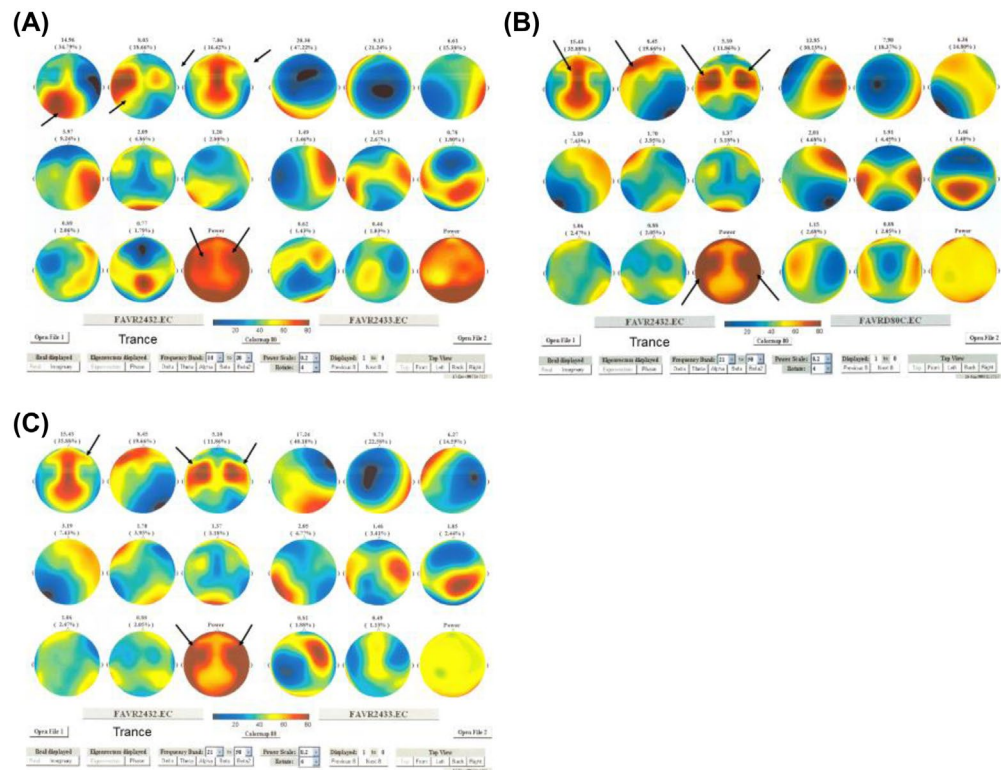
**6.2.2. Quantitative EEG mapping**

In the trance state, the subject shows reduced coherence in the right hemisphere and increased coherence in the left hemisphere in the low beta band compared to the controls (Figure 3(A)). In the high beta band, the pattern is of increased anterior–posterior coherence (fronto-central and occipital, Figure 3(B)). Of particular interest is the presence of two symmetrical foci of increased power

**Figure 2. Centroid analysis.** (A) Centroid analysis of the subject in the trance state (red) vs. 80 normal dextral female controls (blue). (B) Discriminant score comparison of the subject in the trance state (red) vs. 80 normal dextral female controls (blue) and 84 females with depression (yellow). (C) Discriminant score comparison of the subject in the trance state (red) vs. 80 normal dextral female controls (blue) and 19 females with mania (yellow). (D) Discriminant score comparison of the subject in the trance state (red) vs. 80 normal dextral female controls (blue) and 18 females with schizophrenia (yellow).



**Figure 3. Quantitative EEG mapping of the subject in the trance state (left 3 × 3 maps) vs. 78 normal dextral female controls (right 3 × 3 maps): (A) Low beta band, EC condition. (B) High beta band, EC condition. (C) The subject in the trance state (left 3 × 3 maps) vs. in her normal state (right 3 × 3 maps): high beta band, EC condition.**



bilaterally in the centro-temporal regions, which is completely absent in the control condition. This may suggest a trance-specific disruption of inter-hemispheric integration.

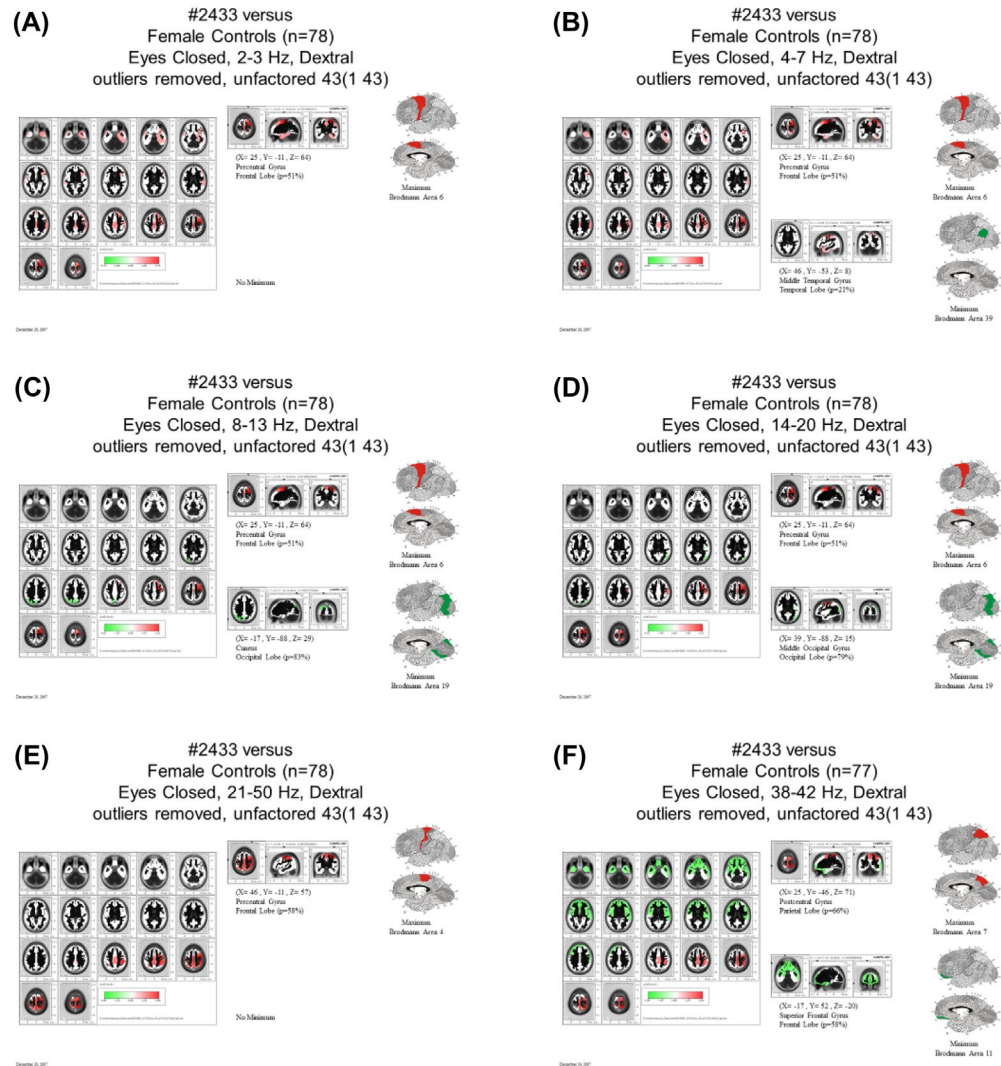
Inspection of the EEG map when the subject is in the trance compared to her normal state (eyes closed—Figure 3(C)) shows a dramatic increase in power in the low and high beta bands, which is bilaterally symmetrical in the mid-temporal/central regions and in the lateral convexity extending across the fronto-parietal zones. In the trance state, the three most significant coherence configuration factors that account for 68% of the variance in the 21–50 Hz band, and 50% in the 14–20 Hz band are characterized by increased midline coherence in the fronto-temporo-parietal regions; increased left fronto-temporal foci; and symmetrical foci of increased coherence in the medial-central temporal regions, respectively.

### 6.2.3. LORETA source analysis

In the normal state, the subject shows increased sources in the right frontal regions in delta, theta, alpha, and low and high beta bands compared to the 78 normal dextral female controls (Figure 4(A)–(E)). There are additional gamma sources in the right post-central gyrus (Figure 4(F)). The anatomical origins of the LORETA sources compared to 78 normal female controls are shifted from anterior to posterior-frontal pre-central gyrus in the subject’s normal state, and further to post-central gyrus and parietal locations in the trance state.

In the trance state, there are increased unilateral sources in the right hemisphere in the delta and theta bands compared to the 78 normal dextral female controls (Figure 5(A)–(B)). These originate from the right inferior temporal lobe (delta) and right parietal lobe (theta). In the alpha band, the sources are increased in both hemispheres, originating in superior temporal gyrus (Figure 5(C)). A similar configuration of symmetrically increased sources in both hemispheres is found in both low and high beta and in gamma bands: frontal for the low beta, and parietal for the high beta and gamma bands (Figure 5(D)–(F)).

**Figure 4. LORETA power source distribution of the subject in the normal state vs. 78 normal dextral female controls, EC condition: (A) Delta band; (B) Theta band; (C) Alpha band; (D) Low beta band; (E) High beta band; (F) Gamma band.**



Specific localization of LORETA power sources in the trance state by the frequency bands compared to 78 dextral female controls demonstrated the following patterns:

*Delta sources (2–3 Hz):* Increased unilaterally, maximally in the right temporal lobe (originates in inferior temporal gyrus, Brodmann area (BA) 20—Figure 5(A)).

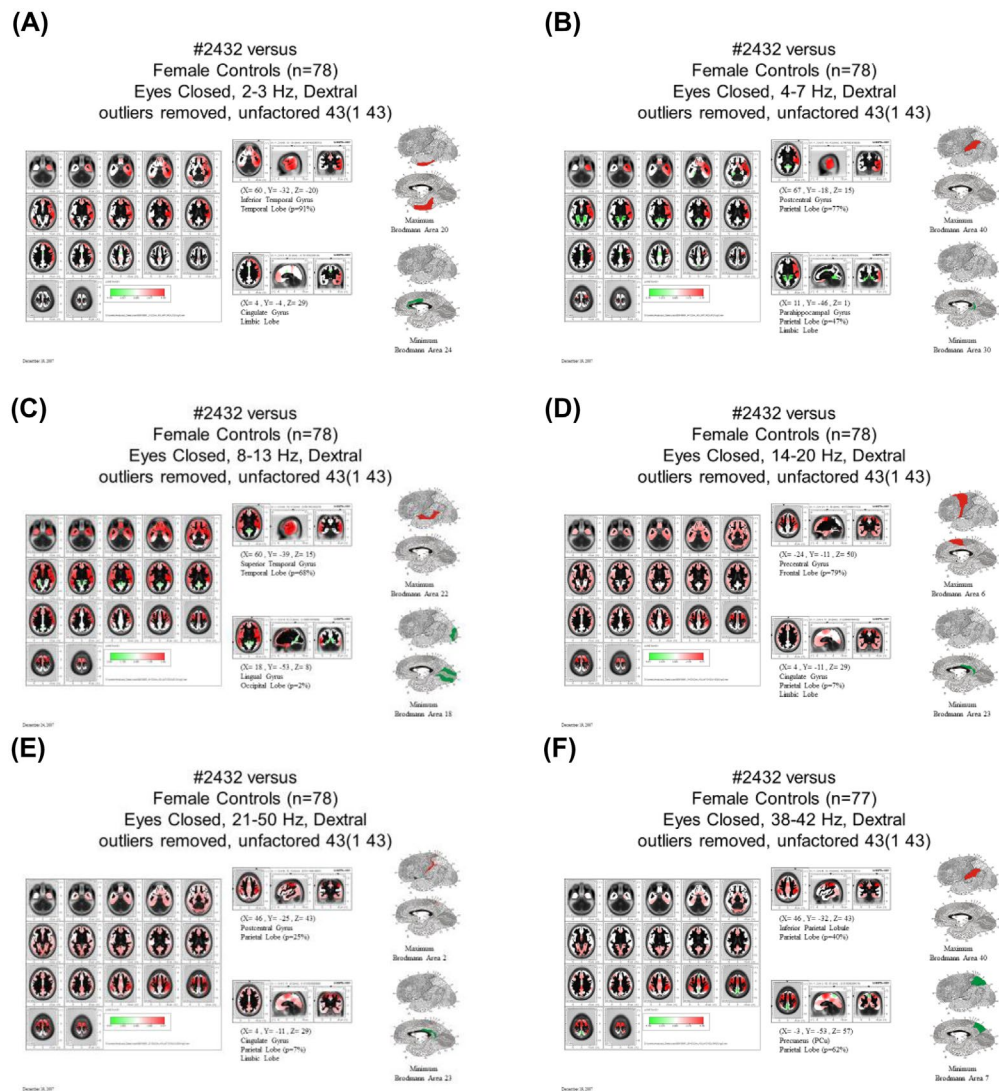
*Theta sources (4–7 Hz):* Increased in the right fronto-temporo-parietal areas (originates in posterior central gyrus, BA 40—Figure 5(B)).

*Alpha sources (8–13 Hz):* Increased bilaterally in the fronto-temporo-parieto-occipital areas, maximally in the temporal lobe (originates in superior temporal gyrus bilaterally, BA 22—Figure 5(C)).

*Low beta sources (14–20 Hz):* Increased bilaterally in the fronto-parieto-occipital areas, maximally in frontal lobe (originates in precentral gyri bilaterally), BA 6 (Figure 5(D)).

*High beta sources (21–50 Hz):* Increased bilaterally in the fronto-temporo-parietal areas, maximally in the parietal lobe (originates in post-central gyri), BA 2 (Figure 5(E)). There is evidence of

**Figure 5. LORETA power source distribution of the subject in the trance state vs. 78 normal dextral female controls, EC condition: (A) Delta band; (B) Theta band; (C) Alpha band; (D) Low beta band; (E) High beta band; (F) Gamma band.**



increased coherence in same regions in both normal (EC) and trance conditions (Figures 4(E) and 5(E)), representing a progression of the same pattern, which is accentuated in the trance state.

**Gamma sources (38–42 Hz):** Increased bilaterally in the fronto-temporo-parietal areas, maximally in the inferior parietal lobule (BA 40)—Figure 5(F).

Alpha power ratios (log R/L) show consistent relative right brain activation in parietal (P4-P3), mid- and posterior temporal (T4-T3, T6-T5), and frontal (F8-F7) areas (Table 2).

Table 2. Lateralized log R/L alpha power ratios in normal vs. trance state		
	Normal (relative left brain activation)	Trance (relative right brain activation)
P4-P3	0.924	-0.250
T4-T3	0.727	-0.247
F8-F7	0.182	-0.318
T6-T5	1.047	-0.217

In summary, the pattern of EEG changes observed during the trance state suggests altered neurophysiological organization in the right hemisphere, inhibitory in nature, maximal in temporo-parietal areas, associated with impaired inter-hemispheric connectivity, and a generalized increase in cortical beta sources. In the transition from the normal to the trance state, there is evidence of an antero-posterior shift, from frontal (delta, theta, alpha, and low and high beta) and parietal post-central (gamma) in the normal state to inferior temporal/parietal (delta), parietal post-central (theta), superior temporal gyrus (alpha), frontal and precentral gyrus (low beta), parietal, post-central gyrus (high beta), and inferior temporal lobule (gamma) during the trance. The underlying neurophysiological changes, preexisting in the right frontal region, may explain the subject's unintentional first experiences of the trance, and relate to the fact that at the age of 11 months, following an allergic reaction to smallpox, she became comatose and had a brief cardiac arrest.

## 7. Discussion

The diverse levels of evidence reviewed to this point range from phenomenological accounts of altered states to anthropological and ethnocultural observations to electrophysiological and neuroimaging data. Brain neuroplasticity stands at the crossroads between subjective and cultural experience, allowing us to conceptualize an emergent discipline of *neuroanthropology*. In his recent review, Northoff (2010) commented that there is “bidirectional traffic between subject and environment that is mirrored in brain’s neuronal activity... which allows ourselves to constitute ourselves as humans and to create the different environments investigated in anthropology” (p. 749). The challenge for the general reader and researcher alike is to integrate these highly specialized threads into an integrated model that may shed light on the mechanisms of trance and ASCs.

Northoff and Heinzl (2006a) made a seminal distinction between conventional “third-person neuroscience” focusing on observable changes in brain function vs. “first-person neuroscience,” in which the contents of the subjective experience are carefully linked to objective observations on a case-by-case basis. They comment that “empirical investigations of brain states focus exclusively on neuronal states and presuppose therefore only the third-person perspective”; however, “in order to reveal the true neuronal correlates of mental states, first- and third-person perspective must be linked to each other, resulting in the systematic ‘science of experience’.” In utilizing this paradigm, we offer parallel subjective and objective correlates of the subject’s shamanic trance experience, which will serve as a foundation for the integrated psychobiological model of SSC, and by extension the entire category of altered states and their relation to normative conscious processes.

### 7.1. The subjective perspective

#### 7.1.1. Experience of trance from 12/10/2007

It was a very light trance, because I was asked not to move a lot. My nose began to tremble as it used to do in the beginning of each trance (now I am able not to move at all). Then my hands and my arms started shaking lightly. An inner vision of a wolf face, very close to my face, came soon after. Then an owl (two close representations are joined). I have to add that these visions were not seen as precisely as they are with our eyes. It may happen that the visions are quite similar to how we see with our eyes, but sometimes it’s more like the feeling of a presence than the image of it. But despite the fact that I don’t really see it, I “know” what or who it is. During that trance too, I perceived some soft sounds and a bit of a song that I didn’t know.

#### 7.1.2. Changes in perception and body awareness

I find myself in a completely dark place (I don’t know if it is the reason why the shamans call it “black world”). The first impression is the loss of time perception, like being in a timeless space. My strength is increased a lot (I can hold and beat the drum, which weighs 8 kg, for hours without any difficulties). My perception of pain is considerably reduced. For instance, at the beginning of my practice, my



body hurt a lot because I had to manipulate the drum made of thick wood. But amazingly each trance was painless, while when I was back to my normal state, I felt a lot of pain in every part of my body. Another effect of the trance is the loss of the perception of cold and heat.

My eyes (closed during every trance) have visions like geometrical patterns, places or entities called spirits by the shamans. They can appear to me as men, or women, or animal patterns, that I can suddenly speak with. I feel like I can also detect discords in my environment. When discord is present, my nose can “smell” it. Or, I guess, it is not the odor but the information at the root of the odor. My hands act like they are responding to these discords by performing gestures that I have absolutely no control over. I also can feel forms (more often like balls) in the air. My hands can turn around, try to soften them or to move them gently. I sing songs I have never sang or even learned, I speak unknown languages, and I perform very complex sounds that I am unable to perform in my normal state.

### 7.1.3. *Changes in thinking and emotional state*

My sense of self seems to be receding because I don't feel like I am myself anymore; I lose the perception of who I am, or who I used to be. I suddenly feel like the animal or the entity I am supposed to be possessed by. As I am a wolf, for example, I can feel paws in place of my hands and a muzzle in place of my nose. I don't speak anymore but howl like a wolf. About the emotional changes, I'd like to say that I can feel I am incredibly at peace but at the same time possess the strength of “a fierce warrior” when it happens that I have to fight what I see as a harmful entity.

## 7.2. *The objective perspective*

The novel contribution of this study is our cardinal observation of the right and posterior shift in the transition to shamanic trance state, with markedly increased fronto-central coherence in the excitatory high beta band bilaterally, extending posteriorly to include parietal and occipital regions. Previous observations (Tsakiris, Costantini, & Haggard, 2008) identify right temporo-parietal junction as a specific substrate in maintaining a coherent sense of one's body (“me” vs. “not me”). Coupled with bilaterally increased power sources in the central temporal regions suggesting a discrete disruption of inter-hemispheric integration, these changes may underlie alterations in the default bodily and autobiographical sense of self that depends on integrated functions of the verbal left and experiential right modes of awareness.

A seminal study of left vs. right hemispheric modes of cognitive processing was undertaken by Vadim Deglin in St. Petersburg (1996), utilizing a false syllogism paradigm before and after unilateral ECT treatments. Under the conditions of the right hemisphere post-ECT suppression (“left self” mode), all linguistic tasks were solved quickly and with more confidence than in the control condition; however, the solutions were limited to the internal consistency of the proposition rather than its correspondence to external reality. For example, in solving a false syllogism:

- (a) Winter is cold in tropical countries
- (b) Ecuador is a tropical country
- (c) Is it cold in Ecuador in winter, or not?

the subject would provide a *theoretical answer* and insist that it is cold in Ecuador “because it says so.” By contrast, under the conditions of the left hemisphere post-ECT suppression (“right self” mode), the same subject would provide an empirical answer and reject the syllogism as wrong because “everyone knows that tropical countries don't have cold winters.” The authors concluded that “under left hemisphere suppression and reciprocal activation of the right hemisphere, when empirical thought dominates, false premises evoke negative emotional responses. Under right hemisphere suppression and reciprocal activation of the left hemisphere, when theoretical thought dominates, false premises are calmly accepted” (p. 303).

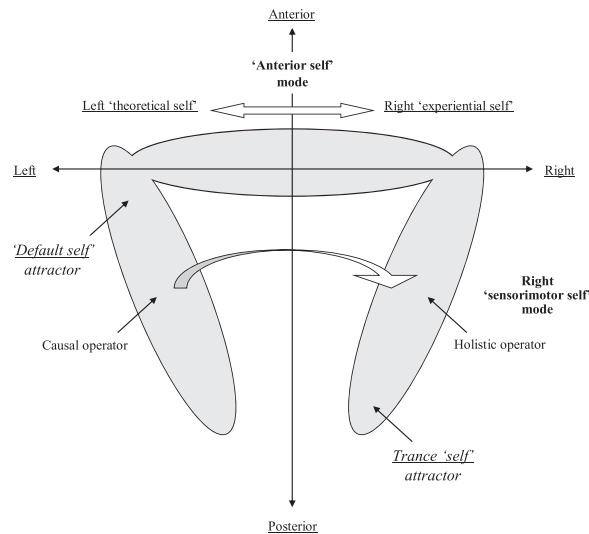
While these findings are consistent with the importance of right frontal regions in reality testing (Lehmann et al., 2001), Newberg and d'Aquili (2000) also identified specific lateralized regions responsible for conscious information processing. The left *causal operator* is responsible for analytical understanding of both external sensory and internal associative information input in the superior parietal lobule and anterior frontal convexity of the dominant hemisphere, and the right *holistic operator* is responsible for generating gestalt understanding of the information input and its correspondence to external reality in the posterior superior parietal lobule of the non-dominant hemisphere (Figure 6).

The novel findings in our study identify an altered balance in the subject's right- vs. left-based modes of awareness, progressing from normal to shamanic trance state. In the normal condition, there is evidence of increased right hemispheric frontal/pre-central power sources in delta and beta bands, and right parietal/post-central sources in gamma band, coupled with increased coherence in the right parietal-occipital and fronto-temporal regions accounting for 40% of the variance, and decreased coherence in the left hemispheric sources accounting for 23%. This is consistent with previous studies of experienced meditators who show persistent changes in the resting, non-meditating state, likely as a result of entrainment of the relevant cortical circuitry following habitual meditation practice (Tei et al., 2009). Such entrainment may also allow for voluntary control of otherwise pathological trance states, and agrees with phenomenological accounts of shamanic practitioners shifting at will between ordinary vs. altered ways of perceiving physical and social reality. The findings of similarities on discriminate function analysis between our subject and depressed, manic, and schizophrenic populations in the high beta band may therefore be related to a disruption in left hemispheric fronto-temporal integration resulting in the release from contralateral inhibition and homologous right hemispheric overactivation, which may represent a common factor in schizophrenic/dissociative psychopathology and in the shamanic trance state. However, the cardinal observation in this study is that the corresponding electrophysiological changes are limited to the trance condition and to a specific band frequency, the subject maintaining the capacity to return to her normal state at will. This capacity for voluntary induction and termination of seemingly pathological brain states coupled with the availability of the internally derived trance information for subsequent analytical processing is the defining characteristic of functional trance states and SSCs, which distinguishes them from psychopathology.

Our observation of increased fronto-central delta, theta, and alpha power sources is also consistent with Carhart-Harris' et al. (2012) evidence of DMN inhibition in psychedelic states and reduced duration of default mode conceptual processing in Zen meditation implicating alterations in attentional networks (Pagnoni, Cekic, & Guo, 2008). The DMN and attentional networks impose top-down control on the lower cortical and limbic networks, effectively gating sensory, affective, and associative information processing into established patterns of self-referential templates in order to minimize prediction errors (Northoff et al., 2006b). The shamanic mode of consciousness may therefore correspond to an altered pattern of self-referential processing due to a release from the ordinary top-down inhibitory control mechanisms, resulting in a wider range of association networks coming into conscious awareness, similar to psychedelic and lucid dream states.

The resultant increase in cortical-subcortical connectivity is evidenced by the bilateral increase in fronto-temporal alpha power and increased fronto-temporal and parieto-occipital low/high beta and gamma sources. Among other functions, alpha oscillations have been shown to underlie temporal attention to visual stimuli (Hanslmayr, Gross, Klimesch, & Shapiro, 2011), and gamma activity may reflect the binding function of diverse aspects of object representation in conscious awareness. These objective data are consistent with our subject's subjective reports of altered self-experience, intense consciously accessible inner imagery, and somatosensory alterations suggesting a shift from verbally driven, ego-bound mode of ordinary consciousness (OSC) toward more visual and somatosensory "right experiential mode" prevalent in altered states. The analysis of alpha power ratios pre- and post-trance induction correspondingly shows relative left brain dominance during the subject's normal conscious state shifting to marked right brain dominance in the trance state.

**Figure 6. Posterior–anterior and lateral axes in normal and altered states of consciousness.**



### 7.3. The unified psychobiological model

Our findings point at a unified clinical model of altered state experiences based on a shift from the left hemisphere-dominant, verbally based, serial mode of information processing in normative conscious awareness to right hemisphere-dominant, somatosensory-based, parallel mode of information processing in OSC states (Figure 6). We can conceptualize this shift occurring on two separate axes:

*The lateral axis* (inter-hemispheric right to left hemispheric processing): increasing information complexity through integration and modulation of implicit experiential and somatosensory-affective experiences into explicit verbal conscious awareness.

- (1) Ordinary left hemisphere-dominant “analytical self” mode allows for a normative conscious state of dual awareness (OSC) with a sense of autobiographical self extended in time, symbolic information processing, abstract capacity, and linear cause–effect attribution. Based on lateralized inhibition of right hemispheric systems through evolutionarily newer left dorsolateral networks.
- (2) Internally or externally induced release from left hemispheric inhibition results in a shift to the right “experiential self” mode (Figure 6), with altered states of awareness (ASCs) accompanied by non-verbal, timeless perception of reality grounded in experiential-gestalt rather than theoretical-analytical domain. Represents uncoupling of the right hemispheric “holistic operator” from the normally dominant left hemispheric “causal operator” networks, manifested in the homologous right hemispheric contralateral overactivation in the fronto-temporo-parietal areas and subjective intrusion of the right hemispheric content into waking awareness.

*The posterior-anterior axis* (subcortical/primary association areas to anterior cortical midline structures): increasing information complexity through the coalescent autobiographical sense of “dual self” possessed of intentionality and willful action planning.

- (1) Ordinary prefrontal-dominant “anterior self” mode allows for “me—not-me” distinction, with an experience of separate self possessing thoughts and emotions interacting with separate others and larger independent reality, as well as subjective sense of “free will”. Based on top-down inhibition of lower affective-somatosensory systems through evolutionarily newer prefrontal cortical structures.
- (2) Internally or externally induced release from prefrontal inhibition results in a shift to the posterior “sensorimotor self” mode, with ASCs accompanied by rich imagery, intense affective experiences,

synesthesias, dissolution of ego boundaries, and cosmic feelings of “oneness” with the Universe. Manifested by relative hypofrontality and “decreased activity and connectivity in the brain’s key connector hubs, enabling a state of unconstrained cognition”. (Carhart-Harris et al., 2012)

The combined picture suggests a correlation between the right-posterior “trance” consciousness mode with the phylogenetically older, reflexive X-system of social cognition (Lieberman, 2007) characterized by implicit, parallel information processing facilitated by high arousal and unaffected by cognitive load. Its outputs are experienced as subjectively real, with blurred demarcation between self and “not-self.” By contrast, the left-prefrontal “default” consciousness mode correlates with the phylogenetically newer, reflective C-system characterized by explicit, serial information processing inhibited by high arousal and cognitive load. Its outputs are experienced as self-generated and distinct from external reality, resulting in dual self/not-self awareness.

We believe that the findings of this study and the proposed psychobiological model have wide-ranging implications for cognitive science and consciousness research. Based on the above model, consciousness and self-awareness are best conceptualized as a *process of experience* rather than discrete “states of consciousness”, whether normal or pathological. Conscious awareness represents a fluid equilibrium between anterior/posterior and right/left modes of experience that constantly shift depending on the individual psychobiology, external information input, and cultural paradigms (Han et al., 2013). The illusion of fixed “states of consciousness” and a subjective self are based on habitually established patterns of information processing that can be conceptualized as *attractor dynamics* encoding diverse patterns of self-experience (Shapiro, 2015). From the dynamical systems perspective, attractors represent adaptive algorithms that carried a survival value in the course of *Homo sapiens* evolution; they determine default patterns of organizing our perceptual, affective, cognitive, and relational experience, and acting on it. Attractor-bound events are fundamentally process oriented, and are best conceptualized as dynamic “modes of conscious experience” rather than static “ordinary” vs. “altered” states.

The “default self” mode of consciousness can therefore be conceptualized as a periodic attractor that involves sleep-wakefulness phases and predominantly operates within the left-anterior analytical network domain (Figure 6). In contrast, the “trance self” mode represents a point attractor that operates within the right-posterior experiential/sensorimotor network domain. The transition between default and trance attractor modes is facilitated by the release of the normative left-hemispheric contralateral and prefrontal inhibition under the conditions of meditative or psychedelic trance techniques. Shamanic and altered modes of consciousness may thus represent a learned voluntary capacity to step aside from the analytical conscious attractor dynamics (default self-awareness) and access alternate ways of experiencing internal and external reality that has been conceptualized as a “nonlocal-intuitive” perspective (Frecka et al., 2016).

#### **7.4. Implications for psychiatry**

In psychiatry, the longstanding separation into biological vs. psychosocial modalities is rapidly growing obsolete: both psychopharmacological and psychotherapeutic interventions effect biological changes in the brain, both are administered in the context of a therapeutic relationship, and both are inseparable from the patient’s subjective experience of the treatment. Conversely, there is consistent evidence that alterations in subjective experience, such as learning and psychotherapy, can induce lasting changes in brain structure and function by effecting epigenetic changes that modify the very synaptic networks that give rise to our subjective experience (Kandel, 1998; Shapiro, John, Scott, & Tomy, 2016a, 2016b). In the words of Nobel laureate Eric Kandel, “insofar as psychotherapy or counseling is effective and produces long-term changes in behavior, it presumably does so through learning, by producing changes in gene expression that alter the strength of synaptic connections” (p. 460).

In addition, a wide range of treatments that would have been considered esoteric only a decade ago, such as mindfulness, hypnotherapy, meditation, and psychedelic and altered state experiences, demonstrate effectiveness in a wide range of depressive, anxiety, and trauma-based syndromes (Masson & Bernoussi, 2014; Pathania, 2015). A recent review of mindfulness practices in mental health (Kok & Singer, 2017) suggests that they are associated with increased positivity of affect, feelings of warmth toward others, metacognitive awareness, and decreased thought distraction. Mindfulness-based stress relaxation (MBSR) and mindfulness-based cognitive therapy (MBCT) have been shown to increase alpha and theta band activity in prefrontal and anterior cingulate networks (Chiesa & Serretti, 2010). Sensorimotor therapy approaches utilize non-verbal, body-oriented modalities to process intense trauma memories (Ogden, Minton, & Pain, 2006), and research into unconscious processes in mental health and psychopathology highlights the essential role of implicit cognition, affective processing, and social cuing that happen outside of verbal conscious awareness and provide the basis for automatic emotional regulation and attachment dynamics (Schoore, 2011).

While in Western psychiatry trance experiences have been largely been viewed as pathological or esoteric, there are diverse cultural traditions where altered modes of consciousness serve the function of healing and self-exploration. With the current resurgence of interest in integrative medicine and complementary healing techniques, understanding the psychobiology of trance states may not only help to “de-pathologize” them in the eyes of medical practitioners but also use them as another therapeutic tool in the psychiatric treatment provision.

## 8. Conclusion

At the onset of this study, we posed two key questions:

- (1) Do shamanic trance states represent psychopathology or an anomalous but non-pathological mode of brain functioning?
- (2) What specific alterations in brain function accompany shamanic trance states? Specifically, are shamanic states characterized by a shift from the normally left hemisphere-dominant mode of conscious awareness to a relative predominance of right hemispheric activation?

The evidence from this study and systematic analysis of existing neurophysiological, neuroimaging, and phenomenological data on the altered modes of consciousness strongly suggest that while there are some parallels to spectral EEG changes in clinical populations, shamanic trance is not a psychopathological condition and cannot be reduced to psychotic or dissociative clinical phenomena. In addition, we corroborated not only generalized right hemispheric dominance during shamanic trance but also a specific shift from the normative anterior prefrontal to the right posterior mode of awareness. There is now enough emerging evidence to begin constructing a comprehensive psychobiological model of trance states, which can inform both the wider field of basic consciousness research and clinical work with pathological consciousness alterations.

The concept of first-person neuroscience can be extended to incorporate *systemic psychobiology* (Shapiro & Scott, *in press*), where brain/mind is seen as a dynamic, nonlinear system with multi-level emergent properties that interact through both bottom-up and top-down causal loops in a continuous diathesis with our internal, physical, and cultural environments. Approaching cognitive science from the perspective of systemic psychobiology allows us to transcend the reductionist brain/mind and nature/nurture dichotomies by utilizing parallel dynamics between four emergent levels of complexity:

- (1) “Third-person” level of observable neural network processes.
- (2) The emergent “first-person” level of subjective experience with associated patterns of perception, feeling, thinking, and intentionality in the course of individual lifespan (emergence of consciousness).

- (3) The emergent “second-person” level of intersubjective experience with associated relational patterns of individual and group interactions.
- (4) The emergent social level of cultural experience associated with stable patterns of interpreting objective and subjective reality that are influenced by the individuals but transcend the individual lifespan.

Our model suggests that subjective conscious experience in ordinary and altered domains, and the brain mechanisms that give rise to them, cannot be understood in isolation from each other and their larger social and cultural contexts. Both brain scientists and clinicians as well as cultural anthropologists have to resist the temptation of reductionist linear models, whether brain, mind or society based. To understand the individual, we must integrate the fluid dynamic of objective third-person data with subjective systems of meaning and the cultural context that gives rise to them. In this view, individual conscious processes are inseparable from their intersubjective milieu and relational, social, and cultural contexts. Therefore, any meaningful exploration of brain changes contributing to conscious experience has to be based on unifying objective, subjective, and intersubjective science in health and psychopathology.

The shift to the evolutionarily older, right hemisphere-dominant mode of awareness may help transcend the established left hemisphere “theoretical” constructs informed by our developmental and cultural interactions, and allow for a novel, gestalt experience of physical and social reality leading to qualitatively different awareness of the problem under consideration (such as our subject’s synesthetic “smell of discord”). The systematic use of the right hemispheric “experiential” mode may thus serve as a tool in allowing SSC practitioners to operate within largely non-verbal, associative awareness, which they tend to experience in visual and somatosensory modalities. Psychoanalytic and Jungian traditions have long emphasized the importance of attending to the unconscious content of experience, and there has been a recent shift in Western schools of psychotherapy from largely verbal to more experiential, nonlinear approaches that integrate affective, somatic, and intersubjective domains (Lyons-Ruth, 2001). These perspectives may help us bridge traditional and Western concepts of psychopathology and mental health treatment, and integrate the current biopsychosocial orientation in psychiatry within a wider evolutionary foundation of systemic psychobiology that incorporates objective, subjective, and intersubjective science.

It is the authors’ sincere hope that more research within the systemic psychobiology framework may help not only to elucidate the neural correlates of ordinary and altered conscious experience, but also to bring about an emergent, non-reductive paradigm of the systematic “science of experience” in neuroscience and clinical psychiatry. To paraphrase William James’ introductory epigraph, no scientific account of the universe in its totality can be final when it leaves out the phenomenon of conscious experience.

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