Original article

Frontal electroencephalographic (EEG) activity and mediumship: a comparative study between spiritist mediums and controls

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Abstract

Mediumship and spirit possession are cultural phenomena found worldwide. The Spiritism, popular in Brazil, is a religious tradition that emphasizes mediumship. The "absorption hypothesis" (the association of marked increases in focused attention with concomitant decreases in self-awareness) is one of the neuropsychological explanatory theories for these experiences. We measured electroencephalographic (EEG) spectral power in frontal electrodes within theta, alpha and beta bandwidths, as well as cross-regional cortical coherences, in female Spiritist experienced mediums (n = 10) and in female non-medium control subjects from the same religious context (n = 10). Scalp EEG signals were captured simultaneously from participants in each of the two groups in three different moments: before, during and immediately after mediumistically speaking. Compared to non-medium controls, the mediums had greater beta power on some electrodes in all phases of the experiment, greater theta power on one electrode at the communication phase and greater alpha power on one electrode at the post-communication phase. No condition effects (within-group comparisons) were detected in any group. No group effects were noted for cross regional cortical coherences. No ictal EEG pattern was observed, except for one participant in the mediums group. These findings support the hypothesis that absorption could have a mechanistic role in anomalous sensorial experiences such as mediumship. The coherence pattern in mediums during the anomalous experience differed from prior studies on pathological dissociation and on hypnotic states. Cognitive control processes seem to be engaged during the anomalous sensorial experiences.

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Introduction

Mediumship can be defined as the alleged ability to communicate with deceased personalities on a regular basis[1]. This is a cultural phenomenon found in almost every society worldwide[2], and it can manifest itself in various forms, *e.g.*, hearing or seeing spirits, spiritual possession, or talking and writing under the influence of spirits, among others. The Spiritism, popular in Brazil, is a religious tradition that emphasizes such experiences. Currently, one of the most widely accepted neuropsychological theories to explain mediumship and other spiritual experiences with sensorial alterations is the "absorption hypothesis"[3]. Absorption is the capacity to direct the focus of attention to externally or an internally (thoughts, emotions, memories) generated stimulus, and to allow that focus to increase while decreasing attention to the multitudinous distractions of daily life. In these circumstances, mental activities of reality monitoring, that is, basic decisions about whether the source of an experience is internal to the mind or external in the world, may be impaired and perceptual "breaks" may result[3,4].

There has been a long discussion within psychology and psychiatry about whether these type of events are real, spontaneous modifications in brain states that reflect basic neurobiological phenomena, or whether they are imaginary, socioculturally constructed role performances. In most Western societies, when a person has sensorial experiences and behaviors felt as the non-self, this is usually interpreted as a sign of mental disease, and the majority of mental health professionals interpret theexternal "agencies" and "communicating spirits" as fragments of the individual's own self and inner conflicts[4,5]. However, other scholars, in light of evidence stemming from controlled studies about the accuracy of mediumistic communications and about "near-death" experiences, consider plausible that some individuals, in altered mental states, could actually communicate through extra-sensorial perception with some form of non-local consciousness[6-8].

Dissociative experiences have been thought to exist on a continuum, ranging from non-pathological absorption through hypnosis, to more profound and prolonged experiences that include dissociative amnesia and alterations in identity (*e.g.*, Dissociative Identity Disorder). Dissociation is widely accepted as a sort of built-in defense mechanism that allows individuals to shield psychologically themselves from extreme emotions and arousal triggered by a traumatic event. However, while some degree of dissociation may be considered adaptive in the short-term, prolonged and/or intense dissociative responses are deemed maladaptive (*e.g.*, dissociative identity disorder, posttraumatic stress disorder). Nevertheless, in some contexts, dissociation is not related to trauma at all, and therefore it likely has very different functional implications[4]. The question of whether pathological and non-pathological dissociation share a common pattern of neural activation and of physiological responses remains open.

Greater pain insensitivity in carriers of dissociative disorders has been associated with higher electroencephalographic (EEG) theta activity[9]. Likewise, both in pathological and non-pathological contexts, EEG theta activity was positively correlated with DES (Dissociative Experiences Scale) scores[9,10]. The coherence is a measure that quantifies the covariation of power spectra within specific frequency bands among pairs of EEG electrodes, being an index of synchronization between cortical areas. Greater coherence between such areas indicates that they are functionally connected[11]. In healthy individuals, situations of great emotional load (which demand engagement of cognitive control mechanisms) have been associated with increased frontal-posterior EEG coherence compared to emotionally neutral conditions[12]. A study investigating EEG coherence in individuals with

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psychogenic nonepileptic seizures (PNES), a dissociative disorder, found decreased fronto-parietal coherence in carriers compared to control participants. Moreover, they found an inverse correlation between the number of events and fronto-parietal coherence[13].

Hypnosis can be defined as a state of focused attention, concentration and inner absorption with a relative suspension of peripheral awareness. Hypnosis has three main components: absorption, dissociation and suggestibility[14]. Based on results of functional neuroimaging studies, some authors argue that highly hypnotizable individuals have frontal attentional systems that work more efficiently[15]. At the basal state, highly hypnotizable individuals usually have greater cortical coherence[16], although some investigators report decreases in frontoposterior synchrony during hypnosis[17]. There is a positive correlation between scores of hypnotizability and EEG theta power[16,17]. Highly hypnotizable individuals have greater probability to report conversive symptoms[16].

The literature about electroencephalographic correlates of culture-bound nonpathological dissociative experiences such as mediumship and possession trances is sparse.

Delorme *et al.*[18] investigated the EEG from six North-American "professional mental mediums" and observed significant correlations for two mediums: in one medium theta power was negatively correlated with accuracy of the mediumistic information, and in the other participant alpha power was positively correlated with accuracy. In the same article, they reported the finding that gamma and beta waves were the frequency bands that could differentiate mediumistic communication and mental tasks of perception. In other study from Indonesia (possession trance during a religious ritual), Oohashi *et al.*[19] reported a case of intense increase of theta and alpha power during the possession trance state (without ictal EEG pattern), persisting in the recovery (post-trance) phase, which was not the case in the control participants. Likewise, in a Brazilian study, Hageman *et al.*[20] analyzed nine Brazilian Spiritist mediums EEG and found an absence of epileptic discharge on the EEG during mediumistic communication, as well as a slowing of background activity in six participants.

Hence, research experiments investigating culture-bound nonpathological dissociation are necessary to advance our understanding of dissociative phenomena and their mechanisms.

EEG is a sensitive non-invasive method with portable technologies that allow it to be used *in situ*, in cultural context[21]. The specific aim of the present field study was to investigate frontal electroencephalographic activity in Spiritist mediums from Brazil and compare them with non-medium control subjects from the same cultural context. Given the findings of research on mediumship to date, it was hypothesized that, in response to the mediumistic experience, significant differences in EEG parameters would be found between mediums and non-medium control participants.

Methods

This is a comparative study carried out in the city of Campo Grande, Brazil from July 2014 to February 2015. As the present report concerns part of a work that had also focused on other peripheral correlates of mediumistic experiences (Bastos Jr. *et al.*, submitted for publication), the methods described below are in part the same as those set in that other manuscript.

Participants

To find qualified mediums, investigators contacted a regulatory organization for Spiritism in Campo Grande, central-west region of Brazil. The board of directors of this institution (Spiritist Federation of Mato Grosso do Sul) indicated that there were five different Spiritist centers, where standardized *disobsession* meetings (a type of Spirit release therapy) took place on a weekly basis.

According to the practitioners of Spiritism, *obsession* may be defined as the persistent action that a morally inferior "spirit" exerts on an individual[22] and the *disobsession* meeting is a common Spiritist practice, where the claimed mediums act as instruments allowing the dialogue with the "spirits"[22,23]. The Spiritist *disobsession* meetings usually include an average of eight to ten participants, each performing one of the following alleged roles: the leader (or *dialoguer*, responsible for enlightening the communicating Spirit); mediums (responsible for speaking under the influence of a Spirit) and support staff (responsible for making mental prayer and energetic irradiation)[23].

For this study, according to the roles they usually played in these meetings, participants were divided into two groups. Ten subjects allegedly capable of mediumistic speaking (mediums group) and ten subjects who were members of the support staff of the meetings (controls group). For each participant recruited for the mediums group (MG), a member of the support staff of the same meeting team was also recruited to constitute the controls group (CG). Study participants were invited consecutively from these centers by two investigators (MAVBJ and DIJ), and the research was presented to candidates as a potential contribution to the scientific understanding of mediumistic experience.

For reasons of convenience, investigators decided to include only adult females in this experiment. In the mediums group, only individuals participating as mediums in *disobsession* meetings for five years or more were included. For the controls groups, the recruitment of a woman of a similar age was tried whenever possible. Exclusion criteria for both groups were pregnancy, people of indigenous origin, smoking, history of severe traumatic head injury or meningitis, diagnosis of cardiovascular disorders (including hypertension), epilepsy, psychiatric illnesses, hypothalamic or pituitary diseases, chronic diseases (*e.g.*, chronic renal failure, lung disease, diabetes mellitus) as well as current use of psychiatric medicines or antiepileptic drugs.

Study design

Data from participants were collected on separate occasions with two subjects on each occasion (one from MG and one from CG). All data collection took place in the Spiritist center that participants usually attended to maintain the routine, format and schedules of the *disobsession* meetings. Each subject participated in only one group, and each subject had been tested and had her data tabulated only once. The EEG signal capturing was undertaken in three different moments: 1) a basal 7-minute recording 30 minutes before the start of the meeting, 2) a recording simultaneous to the mediumistic communication by the medium under study (called *during communication*) and 3) a 7-minute recording immediately after the mediumistic communication (called *post-communication*). At each data collection, the same experimental procedures were undertaken simultaneously for both groups (MG and GC).

Self-reported instruments

Participants answered the following questionnaires prior to each experiment session:

- The Questionnaire on mediumship (adapted from Negro Jr. *et al.*)[24]: consisted of simple questions to assess the degree of training, frequency and nature of mediumship behavior of participants. Moreover, at the end of the experiment, MG participants were also asked to fill out a self-reported scale (10 cm-long line, numbered from zero to ten) rating whether the experimental procedures had any influence on their mediumistic communication, with 0 meaning no influence at all and 10 meaning a very serious influence.
- The Anomalous Experiences Inventory (Menezes Jr. *et al.*)[25] is a fourteen-item multiplechoice instrument where participants report which of the following anomalous experiences (AE) have already happened to them: apparitional experiences, spiritual hearing, spiritual perception, abnormal dreams, out-of-body experiences, foretelling, unexplained loss of energy, possession, intuition, spiritual perception of odors,

physical manifestations of spiritual cause, psychography, telepathy and spiritual healing.

- Mental health was assessed with the "Self-Report Psychiatric Screening Questionnaire" [SRQ-20] validated in Portuguese[26]. This is a 20-item questionnaire formulated to detect common mental disorders, at the primary care level. It covers three groups of symptoms: negative affect (9 items), somatic complaints (8 items), and hopelessness (3 items). Seven or more positive (yes) answers suggest a mental disorder.
- Quality of life was assessed with the "12-Item Health Survey – SF12" [Short Form-12 or SF-12; Quality Metric Inc.] validated in Portuguese[27]. This is a selfreport multidimensional instrument of quality of life, which comprises twelve items grouped into physical or mental health components. The final score can range from 0 to 100, where 0 corresponds to worse general health and 100 to the best health status.
- The Subjective State Evaluation[28] is a well-being scale (10 cm-long line, numbered from zero to ten), containing questions on general well-being, peace, happiness, spiritual well-being, nervousness and irritability during the week in which the experiment was undertaken.

Electroencephalogram (EEG)

During all phases of electroencephalographic signal acquisition, the ambient lights were diminished, all the subjects were sat comfortably with the eyes closed and they were asked to avoid blinking or moving to minimize the amount of muscular artifacts. For signal acquisition, two identical pieces of Neuromap EQSA260 (Neurotec, Itajubá, MG) EEG equipments, with 22 chanels, were used. Pass filters were configured for 0.5-70 μV and Notch 60Hz filters were used. The use of such filters is of paramount importance in field studies as this one, given that the 60Hz noise artifacts due to inadequate grounding of the electric circuits from the data collection sites may otherwise seriously contaminate the EEG records. The tin electrodes were fixed on the scalp with electroconductive paste according to the 10.20 International System[29].

The signal captured on a certain electrode was the result of the difference in the electric potential between that site of the scalp and the pre-established reference. The impedance levels on each electrode were assessed "a priori" through visual analysis of the EEG trace and with impedance tests of the equipment software. Electrode impedance levels lower than 20 K Ohms were sought. After each experimental mediumistic meeting, the digital files with the EEG records of participants were e-mailed to the neurophysiologist of the research team (KARCM) that imported the files to the Neuromap EQSA260 software and then blindly assessed the EEG data.

The EEG data were extracted from 2-second epochs (20 epochs for each phase of recording) and various EEG montages were used, mainly Cz reference and ear reference. Thorough visual inspections of the EEG traces were undertaken, so that only epochs free of muscular artifacts were selected. Taking into account that in communication phase the mediums were dialoguing and that this could contaminate the trace with muscular artifacts, the moments in which mediums were talking were not selected for analysis. All EEG records were assessed to evaluate the presence of ictal pattern. The spectral power densities were estimated and the power in the following frequency bands were determined: delta [0-3.9Hz], theta [4-7.9Hz], alpha [8-12.9] and beta [13-32Hz]. It was not possible to analyse data from gamma frequency [30-70Hz] because the built-in frequency range of the equipments that were used was the 0-32Hz range. We opted not to include data of delta power in the statistical analysis band, as blinking and body movement artifacts more commonly contaminate this frequency range[29].

The available evidence strongly suggests an association between frontal cortex areas with motivation, planning and emotion control mechanisms. As these areas are widely accepted as being involved with spiritual experiences (reviewed in Peres and Newberg, 2013)[30], in the present study only spectral power from frontal electrodes (Fp1, Fp2, F3, F4, F7 and F8) were used for the final analysis. Before the statistical analysis, spectral power values were converted to the unit Log [μV2] /Hz, given that this is the most frequently unit used in recent studies on mediumship[18]. The other EEG variables that were assessed were background activity, percent time in which each frequency band (% delta, % theta, % alpha and % beta) was observed and coherence.

The literature indicates that long distances cerebral coherence occurs mainly in the beta[12] and in the theta[31] frequency bands. Therefore, in the present study, the following electrode pairings were examined – nine frontal interhemispheric: Fp1-Fp2, Fp1-F4, Fp1-F8, F3-Fp2, F3-F4, F3-F8, F7-Fp2, F7-F4, F7-F8; nine left interhemispheric: Fp1-T5, Fp1-P3, Fp1-O1, F3-T5, F3-P3, F3-O1, F7-T5, F7-P3, F7-O1; nine right interhemispheric: Fp2-T6, Fp2-P4, Fp2-O2, F4-T6, F4-P4, F4-O2, F8-T6, F8-P4, F8-O2, both in beta and in theta frequency range. In order to reduce the number of statistical tests required, we grouped coherence pairs into anatomically valid clusters, corresponding to the left and right, prefrontal and posterior association cortex regions (left frontal cluster: Fp1, F3 and F7; left posterior cluster: T5, P3 and O1; right frontal cluster Fp2, F4 and F8; right posterior cluster: T6, P4 and O2), and coherence was averaged (adapted from Miskovic and Schmidt, 2006).

Statistical analysis

The data collected were entered to the SPSS 20.0 statistics package (IBM Corporation, Armonk, USA). Demographic and psychometric data for the groups were compared using the Chi-square test (categorical variables) and Mann-Whitney test (ordinal variables). Electroencephalographic data (continuous variables) from pre-communication, during communication and post-communication phases were subject to independent *t*-tests with a between-subject factor of group (mediums group *vs.* control group). Because there were three moments of electroencephalographic data collection, one-way repeated-measures ANOVA tests were performed to determine within-group condition effects (pre, during and post-communication). Then, a Bonferroni post hoc analysis was performed. A p value < 0.05 was considered statistically significant and the confidence interval was set at 95%. *Values* are *reported* as *means* **±** *standard error of means (SEM).* An independent statistician conducted all statistical analyses under blind circumstances.

Ethical issues

The study was approved and monitored by the Institutional Review Board of the Federal University of Mato Grosso do Sul (ethical appraisal n. 625.917). The study was carried out in accordance with the International Ethical Guidelines and Declaration of Helsinki. All participants, as well as the legal representatives of the Spiritist centers involved, received written and verbal information about the experiment and gave written consent prior to enrollment.

Results

Sociodemographics

Twenty healthy Brazilian females (age: 50.9 ± 3.1 years) participated in this study (10 for the CG and 10 for the MG). All of them live in the city of Campo Grande, and most of them were married (75% [15/20] *vs*. 15% [3/20] single), Caucasian (70% [14/20]) and had attained a high educational level (100% [20/20] had graduated college or graduate school). No difference in participants' age (MG: 57,2 ± 2.8 *vs*. CG: 44.6 ± 4.9 years, p = 0.09), marital status (p = 0.30), ethnicity (p = 0.71) or educational level (p = 0.51) was noted between the groups.

Self-reported instruments

Subjects in the MG had volunteered as mediums at the religious centers for a long period of time (22.8 ± 3.3 years; range, 7 to 40 years), most of them acted as mediums (9/10) for more than ten years. They reported first manifesting symptoms of mediumship by 19.9 ± 3.7 years of age (range, 3 to 38 years). Half of the mediums (5/10) described full consciousness during psychophony, whereas some (4/10) reported partial consciousness and only one described complete unawareness during the phenomenon. All subjects reported being in control of the mediumship phenomenon: most of them (6/10) reported always being in complete control, and the others (4/10) reported to be frequently in control of the experience. All mediums (10/10) reported to have formal mediumship training, which consisted of religious courses (weekly meeting and supervision with a duration of one year or more). Most of the subjects in the MG reported very little influence of the experiment procedures on their mediumistic communication (0-10 scale): 0.2 ± 0.2 (range, 0-2).

Subjects in the MG reported a significantly higher number of anomalous experiences than the subjects in the CG (8.0 ± 0.9 *vs.* 2.7 ± 0.5, p = 0.001). No differences in subjects' mental health were noted between the groups. Mean SRQ scores of the MG and CG was 2.0 ± 0.6 *vs.* 3.3 ± 1.0, p = 0.43. All subjects in the MG scored lower than the cut-off of 7 positive (yes) answers, whereas two participants in the CG scored higher than the cut-off (tracking an increased probability of developing common mental disorders). No difference in participants' quality of life was noted between the groups. Mean SF-12 scores of the MG and CG was 55.9 ± 1.2 *vs.* 50.6 ± 3.1 (p = 0.12) for mental health component, and 56.9 ± 1.2 *vs.* 55.0 ± 2.2 (p = 0.39) for physical health component. All of these mean scores are about average compared to the general population. No difference in participants' well-being (Subjective State Evaluation) was noted between the groups (data not shown).

Electroencephalogram (EEG)

There were valid EEG data from the pre-communication and the communication phases of all participants from both groups (GM: n = 10 and GC: n = 10), however, from the post-communication phase there were valid EEG data from only five participants from each group. It occurred because some participants were also taking part in another experiment, in which they asked to withdraw the EEG electrodes and undertake other measurement procedures after the communication (reported in Bastos Jr. *et al.* – submitted for publication). Before EEG recording, the electrodes impedance levels has been checked through visual analysis in every participant. However, the checking of electrodes impedance levels through the equipment software test was not undertaken in every occasion given the scarcity of time (as it was a field study and the preservation of customary schedules and structures of the meetings was sought).

In the pre-communication phase, mediums had higher mean beta power than non-medium controls on the following electrodes Fp2 (p = 0.001), F4 (p = 0.040), F7 (p = 0.035) and F8 (p = 0.026) (Table 1).

In the communication phase, mediums had higher mean beta power than non-medium controls on the electrodes F7 (p = 0.043) and F8 (p = 0.032), and higher mean theta power on the electrodes F7 (p = 0.014) (Tables 1 and 2).

In the post-communication phase, mediums had higher mean beta power than nonmedium controls on the electrodes F8 (p = 0.031), and higher mean alpha power on the electrodes F4 (p = 0.037) (Tables 1 and 3).

No group effect was noted for the background activities or for the frontal interhemispheric, the left frontal-posterior or the right frontal-posterior coherences. Likewise, no group effect was noted for percent time in which each frequency band was observed, except for a significantly greater percent of theta rhythm in the non-medium controls' group compared to MG (p = 0.035), at the post-communication phase (Table 4).

No condition effects (intra-group comparisons pre-, during and post-communication) were detected for any of the electroencephalographic parameters, as assessed by one-way repeated-measures ANOVA tests, followed by Bonferroni corrections (data not shown). During communication, there was a slowing of mean background activity in the MG and, conversely, an acceleration of mean background activity in the CG, which was accentuated at the post-communication phase. However, these between-group differences did not reach statistical significance. A slowing of alpha background activity was observed in 4/10 participants in the MG and in 1/10 participants in the CG.

Table 1. Between-group comparisons of beta power (Log [μV²/Hz]) in frontal electrodes – pre, during and post-communication

	Pre-communication			During communication			Post-communication		
	Mediuns	Controls	p+	Mediuns	Controls	p+	Mediuns	Controls	p+
	Mean ± SE[a]	Mean ± SE		Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
B-Fp1	0.2 ± 0.1	0.1 ± 0.1	0.628	0.4 ± 0.2	0.0 ± 0.2	0.094	0.2 ± 0,1	0.0 ± 0.2	0.261
B-Fp2	0.4 ± 0.0	-0.1 ± 0.1	**0.001***	0.3 ± 0.3	0.0 ± 0.1	0.231	0.1 ± 0.2	-0.3 ± 0.2	0.182
B-F3	0.2 ± 0.1	0.0 ± 0.1	0.235	0.3 ± 0.2	0.0 ± 0.1	0.213	0.3 ± 0.1	-0.1 ± 0.1	0.060
B-F4	0.2 ± 0.1	0.0 ± 0.1	**0.040***	0.4 ± 0.1	0.0 ± 0.1	0.106	0.3 ± 0.1	-0.1 ± 0.1	0.061
B-F7	0,2 ± 0.1	0.0 ± 0.1	**0.035***	0.4 ± 0.1	0.0 ± 0.1	**0.043***	0.2 ± 0.1	-0.1 ± 0.1	0.086
B-F8	0.2 ± 0.1	0.0 ± 0.0	**0.026***	0.4 ± 0.1	0.0 ± 0.1	**0.032***	0.3 ± 0.1	-0.1 ± 0.1	**0.031***

[a] Standard error of the mean/+ Independent *t*-test/ * p < 0.05.

Table 2. Between-group comparisons of theta power (Log [μV²/Hz]) in frontal electrodes – pre, during and post-communication

	Pre-communication			During communication			Post-communication		
	Mediuns	Controls	p+	Mediuns	Controls	p+	Mediuns	Controls	p+
	Mean ± SE[a]	Mean ± SE		Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
T-Fp1	1.2 ± 0.1	1.1 ± 0.1	0.521	1.2 ± 0.1	0.9 ± 0.1	0.074	1.1 ± 0.1	1.0 ± 0.0	0.123
T-Fp2	1.0 ± 0.2	1.0 ± 0.1	0.916	1.1 ± 0.1	0.8 ± 0.1	0.159	0.9 ± 0.1	0.7 ± 0.2	0.360
T-F3	1.1 ± 0.1	1.0 ± 0.1	0.549	1.1 ± 0.1	1.0 ± 0.0	0.230	1.1 ± 0.0	1.0 ± 0.0	0.116
T-F4	1.2 ± 0.1	1.0 ± 0.1	0.261	1.1 ± 0.1	1.0 ± 0.0	0.106	1.1 ± 0.1	1.0 ± 0.1	0.456
T-F7	1.3 ± 0.1	0.9 ± 0.0	0.082	1.1 ± 0.0	0.9 ± 0.1	**0.014***	1.0 ± 0.0	1.0 ± 0.1	0.679
T-F8	1.2 ± 0.1	1.0 ± 0.0	0.288	1.1 ± 0.1	1.0 ± 0.0	0.098	1.0 ± 0.1	1.0 ± 0.0	0.895

[a] Standard error of the mean/+ Independent *t*-test/* p < 0.05.

Table 3. Between-group comparisons of alpha power (Log [μV2/Hz]) in frontal electrodes – pre, during and post-communication

	Pre-communication			During communication			Post-communication		
	Mediuns	Controls	p+	Mediuns	Controls	p+	Mediuns	Controls	p+
	Mean ± SE[a]	Mean ± SE		Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
A-Fp1	1.1 ± 0.1	1.0 ± 0.1	0.685	1.2 ± 0.1	0.9 ± 0.1	0.240	1.2 ± 0.1	0.7 ± 0.1	0.077
A-Fp2	0.8 ± 0.3	0.9 ± 0.1	0.811	1.1 ± 0.1	0.9 ± 0.2	0.323	1.1 ± 0.1	0.5 ± 0.2	0.075
A-F3	1.2 ± 0.1	1.0 ± 0.1	0.439	1.2 ± 0.1	1.0 ± 0.1	0.391	1.3 ± 0.1	0.8 ± 0.1	0.056
A-F4	1.3 ± 0.1	1.0 ± 0.1	0.173	1.3 ± 0.0	1.0 ± 0.1	0.218	1.3 ± 0.1	0.7 ± 0.1	**0.037***
A-F7	1.1 ± 0.1	0.9 ± 0.1	0.206	1.2 ± 0.1	0.9 ± 0.1	0.213	1.1 ± 0.1	0.7 ± 0.1	0.071
A-F8	1.1 ± 0.1	1.0 ± 0.1	0.384	1.2 ± 0.0	1.0 ± 0.1	0.221	1.1 ± 0.1	0.8 ± 0.1	0.098

[a] Standard error of the mean/+ Independent *t*-test/* $p < 0.05$.

Table 4. Between-group comparisons of electroencephalographic parameters (background activity, relative percent of the frequency bands, coherences in beta and theta bands) – pre-, during and post-communication

	Pre-communication			During communication			Post-communication		
	Mediuns	Controls	p+	Mediuns	Controls	p+	Mediuns	Controls	p+
	Mean ± SE[a]	Mean ± SE		Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
Background activity (Hz)	9.4 ± 0.3	9.2 ± 0.5	0.656	9.0 ± 0.4	9.3 ± 0.4	0.702	8.8 ± 0.5	9.7 ± 0.3	0.207
% delta	25.7 ± 3.3	26.8 ± 1.8	0.781	22.0 ± 2.5	22.1 ± 2.3	0.972	20.5 ± 1.9	25.2 ± 2.4	0.162
% theta	16.7 ± 0.8	17.5 ± 0.5	0.428	14.6 ± 0.8	16.5 ± 0.8	0.118	15.6 ± 0.7	18.3 ± 0.7	**0.031***
% alpha	22.9 ± 1.5	24.6 ± 1.7	0.478	21.9 ± 1.9	25.7 ± 2.2	0.238	25.0 ± 3.4	21.1 ± 1.9	0.356
% beta	33.5 ± 2.9	30.9 ± 1.3	0.421	40.4 ± 3.9	35.8 ± 2.7	0.352	38.8 ± 4.1	35.2 ± 1.2	0.441
Beta-Frontal IH[b] Coherence	0.63 ± 0.4	0.55 ± 0.0	0.132	0.65 ± 0.0	0.55 ± 0.0	0.206	0.66 ± 0.1	0.60 ± 0.0	0.509
Beta-Left FP[c] coherence	0.44 ± 0.5	0.42 ± 0.0	0.712	0.48 ± 0.0	0.45 ± 0.0	0.643	0.46 ± 0.0	0.48 ± 0.1	0.802
Beta-Right FP coherence	0.52 ± 0.5	0.41 ± 0.0	0.077	0.51 ± 0.0	0.45 ± 0.0	0.059	0.56 ± 0.0	0.51 ± 0.0	0.548
Theta-Frontal IH coherence	0.66 ± 0.0	0.60 ± 0.0	0.317	0.69 ± 0.0	0.60 ± 0.0	0.198	0.69 ± 0.0	0.66 ± 0.0	0.570
Theta-Left FP coherence	0.43 ± 0.1	0.47 ± 0.0	0.598	0.47 ± 0.0	0.44 ± 0.0	0.606	0.46 ± 0.0	0.50 ± 0.1	0.561
Theta-Right FP coherence	0.52 ± 0.0	0.44 ± 0.0	0.253	0.48 ± 0.0	0.47 ± 0.0	0.737	0.51 ± 0.0	0.52 ± 0.0	0.855

[a] Standard error of the mean/[b] Interhemispheric/[c] Frontal-posterior/+ independent *t*-test/* $p < 0.05$.

No ictal EEG pattern was observed in any of the participants in the CG in any phase of the experiment, whereas one participant in the MG had an ictal pattern in pre-, during and post-communication phases of the experiment. Posteriorly, this participant was submitted to a standard electroencephalogram in a Neurology Clinic, out of the mediumistic meeting context, which was considered as a normal exam both by the Clinic staff as by the research team Neurologist. She had no history of epilepsy and she remained asymptomatic until the writing of this manuscript.

Discussion

In the present field study, we found differences in the frontal electroencephalographic activity between women allegedly experiencing mediumistic communication and nonmedium control women from the same cultural context. Compared to non-medium controls, the mediums had greater beta power on some electrodes in all phases of the experiment (four electrodes at the pre-, two electrodes at the communication phase and one electrode at the post-communication phase), greater theta power on one electrode at the communication phase and greater alpha power on one electrode at the post-communication phase. Nevertheless, no condition effects (within-groups comparisons pre-, during and post-communication) were detected for any of the electroencephalographic parameters.

These findings corroborate with previous studies that have suggested an association of mediumistic and spirit possession experiences with greater theta and beta power[18,19], as well as an association of dissociation with greater theta power[9,10]. However, contrary to the cases reported by Oohashi *et al.*[19] and Delorme *et al.*[18], we found no between-group difference in alpha power during the mediumistic communication.

In fact, increases in beta and theta power usually reflect higher demands over brain attentional system to acomplish tasks[32,33]. A classic experimental model which puts into evidence this condition is the color-word interference test (or *Stroop* test). In this model, a conflict is created between an incongruent color and word (*e.g.*, the word "blue" in font-color red) and, when the person is asked to name the color, the response time is slower than when the font-color matches the word (*interference*). It has been shown that the slower response time in the former case occurs because it requires more attention to monitor salient information, to suppress irrelevant information and to select appropriate responses[34]. In addition, direct correlations between the extent of interference and theta power, as well as between the extent of interference and prefrontal-posterior coherence (reflecting the engagement of cognitive control mechanisms) have been shown[31,35]. Likewise, other researchers have found significant increases of theta and beta activities as a result of prolonged intensive mental loading (calculation and choice-reaction tasks)[33,36,37]. Therefore, we consider it plausible that the greater beta and theta power observed in mediums in response to the unusual sensorial perception could result from involuntary hesitation and, akin to classic the Stroop test, increased attention demands to suppress inappropriate behavior and to fulfil the socially modeled task appropriately.

We found significantly greater alpha power on one electrode (F4) in mediums at the post-communication phase, which could be interpreted as reflecting cortical rebound resynchronization after the peak of mental arousal (with cortical desynchronization) that seems to have occurred during the communication phase[32,38]. No condition effect was observed for any electroencephalographic parameter in any group, we hypothesize this occurred as a result of the small sample size and because part of the electrocortical changes (*e.g.*, mental arousal) were already present at the pre-communication phase and persisted to the immediately post-communication phase.

Although the between-group difference was not statistically significant, we noted greater prevalence of slowing of EEG background activity in mediums compared to non-medium controls, replicating the findings of Hageman *et al.*[20] and Oohashi *et al.*[19]. Klimesch[32] states that during the performance of a cognitive task there may be phasic changes on the EEG background activity and that a phasic slowing of the alpha rhythm reflects engagement of attentional neural processes, whereas a phasic acceleration of the alpha rhythm reflects engagement of memory mechanisms. Hence, this information corroborates the spectral power findings of the present study and reinforces the hypothesis of predominance of attentional processes in mediums during and immediately after communication. Moreover, the participants in the CG had greater percent of theta rhythm at the post-communication phase and this may indicate greater somnolence in these individuals at this phase of the experiment[39].

Contrary to the pattern of decreased synchronization that has been described to occur in pathological dissociation[13] or during hypnosis[17], in the present study, the analyses of clusters of electrodes revealed no between-group differences in frontal interhemispheric, left frontal-posterior or right frontal-posterior coherences whether in theta or in beta frequency range. In fact, in mediums' group, a nonsignificant increase in average frontal interhemispheric and left frontal-posterior coherence was noted, both in theta and in beta frequency range. In the field of mediumship, many previous studies have underscored the fundamental role of training and the importance of the number of years of work as socially sanctioned mediums to the mental health and adaption of individuals[24,25,40]. Contrary to novices, expert mediums are able to control the experiences and do not report suffering related to the anomalous sensorial experiences, in a process that clearly involves learning and cognitive control. As participants in the MG were expert socially sanctioned mediums, a normal or high level of brain coherence during the anomalous experience could be anticipated, reflecting high cognitive control. A different pattern of brain coherence might have been found if participants were novice mediums[41].

The present study has limitations that should be mentioned. First, the exclusively female sample hinders any extension of study conclusions to males. Second, the small sample precludes any subgroups analysis. Third, because of a limitation of the EEG equipments used we did not analyze gamma band activity, which could also be enlightening. Finally, we did not conduct a baseline assessment of trait absorption. Scores on scales assessing this personality trait could potentially correlate with the physiological findings.

Conclusions

Taken together, the findings of the present study provide support for the hypothesis that absorption can have an important mechanistic role in anomalous sensorial experiences like mediumship and culture-bound spirit possession[3]. Replicating the few available prior EEG studies on this research field[18,19], we observed that mediums had greater theta and beta power during the anomalous sensorial experience compared to non-medium controls. The lack of reduction in frontal interhemispheric and frontal-posterior coherence in mediums group during the alleged mediumistic communication clearly differs from the coherence pattern reported in pathological dissociation[13] and during the hypnotic state[17]. The EEG spectral power and connectivity data observed in this sample of experienced and mentally healthy mediums suggest that cognitive control processes seem to be engaged during the anomalous sensorial experiences. Further research on electroencephalographic correlates of mediumship is encouraged to evaluate gamma band activity, as well as to determine whether the described changes also occur in male mediums.

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Conflict of interest

All authors declare that they have no conflict of interest. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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